IRC:SP:99-2023

MANUAL OF SPECIFICATIONS & STANDARDS FOR EXPRESSWAYS

(First Revision)

INDIAN ROADS CONGRESS

2023

IRC:SP:99-2023

MANUAL OF SPECIFICATIONS AND STANDARDS FOR EXPRESSWAYS

(First Revision)

Published by:
INDIAN ROADS CONGRESS
Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

JAUNARY, 2025

Price: ₹1500/-
(Plus Packing & Postage)

IRC:SP:99-2023
Manual of Specifications and Standards for Expressways

Author's Name
Indian Roads Congress

Published by
Indian Roads Congress

Publisher's Address
Kama Koti Marg, Sector-6, R.K. Puram, New Delhi-110 022

Printer's Details
P.P. Enterprises, New Delhi-110055

Edition Details
First Published, November, 2013
First Revision, July, 2023
Reprinted, January, 2025

(All Rights Reserved. No part of this publication shall be reproduced, translated or transmitted in any form or by any means without the permission of the Indian Roads Congress)

200 copies

CONTENTS

SI. NO.	DESCRIPTION	PAGE NOS.
Personnel of the General Specifications & Standard Committee (GSS)		i-ii
Introduction		1
Section-1	General	5
Section-2	Geometric Design and General Features	36
Section-3	Grade Separators and Interchanges	54
Section-4	Embankment and Cut Sections	62
Section-5	Pavement Design	67
Section-6	Design of Structures	74
Section-7	Tunnels	89
Section-8	Materials	100
Section-9	Drainage	101
Section-10	Traffic Control Devices, Road Safety Devices and Road Side Furniture	108
Section-11	Traffic Management Systems	136
Section-12	Toll Plazas	137
Section-13	Project Facilities: Service Areas, Pick-Up Bus Stops, State Border Check Posts	167
Section-14	Environmental and Social Aspects, Landscaping and Tree Plantation	184
Section-15	Lighting	187
Section-16	Operations and Maintenance	190
Appendix-1		221
Appendix-2		225

PERSONNEL OF THE GENERAL SPECIFICATIONS AND STANDARDS COMMITTEE (GSS) (As on 11th June, 2022)

1	Nirmal, S.K. (Convenor)	Addl. Director General (Nodal), Ministry of Road Transport & Highways, New Delhi
2	Prasad, Ravi (Co-Convenor)	Addl. Director General, Ministry of Road Transport & Highways, New Delhi
3	(Member-Secretary) Vacant	The Chief Engineer (S&R), Ministry of Road Transport & Highways, New Delhi
		Members
4	Agrawal, Akhilesh	Engineer-in-Chief, Public Works Department, MP
5	Bansal, M.C.	Director General (Special) (Retd.), Central Public Department
6	Basu, Kaushik	Chief Engineer (Monitoring), Ministry of Road Transport & Highways, New Delhi
7	Baswana, Brig. C.S.	Deputy Director General (PP & Co-ord), Border Roads Organisation
8	Bhardwaj, Shruti Rai	Scientist E, Ministry of Environment Forest and Climate Change
9	Dey, Ashim Kanti	Professor, National Institute of Technology, Silchar
10	Gangopadhyay, Dr. S.	Director (Retd.), Central Road Research Institute
11	Garg, Anil Kumar	Chief Engineer (Retd.), Public Works Department, Rajasthan
12	Gupta, D.P.	DG (RD) & AS (Retd.), Ministry of Road Transport & Highways, New Delhi
13	Gupta, Manoj Kumar	Engineer-in-Chief, Public Works Department, Uttar Pradesh
14	Guruvittal, U.K.	Chief Scientist, Central Road Research Institute
15	Kapila, K.K.	Chairman & Managing Director, Intercontinental Consultants & Technocrats Pvt. Ltd.
16	Khandelwal, S.S.	Associate Director, Consulting Engineering Group Ltd. Jaipur
17	Kulshreshta, Anoop	Secretary (Retd.), Public Works Department, Rajasthan
18	Kumar Dr. Ashok	Sr. Highway Engineer, World Bank
19	Kumar, Manoj	DG(RD) & SS (Retd.), Ministry of Road Transport & Highways, New Delhi
20	Kumar, Manoj	Member (Projects), National Highways Authority of India, New Delhi
21	Meena, Chinn Hari	Secretary, Public Works Department, Rajasthan
22	Patelia, P.R.	CE (R&B), Public Works Department, Gujarat
23	Parsekar, U.P.	PCE, Public Works Department, Goa
24	Pipri, K.K.	CE (NH), Public Works Department, Chattisgarh
25	Pradhan, Dr. B.C.	Director (Technical), National Rural Infrastructure Development Agency

26	Rajoria, K.B.	Engineer-in-Chief (Retd.), Public Works Department, New Delhi
27	Raju Dr. G.V.S. Suryanarayana	Engineer-in-Chief (Retd.), Public Works Department, Hyderabad
28	Rao, P. Ravindra	Engineer-in-Chief, Public Works Department, Telanagana
29	Reddy, Dr. K.S. Krishna	Secretary, Public Works Department, Karnataka
30	Salunkhe, Sadashiv S.	Secretary (Roads), Public Works Department, Maharashtra
31	Sangma, C.N.	SE, Public Works Department, Meghalaya
32	Sarkar, Dr. P.K.	Professor, School of Planing and Architecture, New Delhi
33	Sharma, R.S.	Chief Engineer (Retd.), Ministry of Road Transport & Highways & Managing Director, Shalimar Tar Products Ltd.
34	Singh, B.N.	Director General (RD) & SS (Retd.), Ministry of Road Transport & Highways, New Delhi
35	Singh, Devendra	Executive Director (P), National Highways and Infrastructure Development Corporation Ltd.
36	Singh, Mahabir	Chairman-Cum-Manging Director, Indian Highways Management Company Ltd. National Highway Authority of India, New Delhi
37	Singh, Nirmaljit	Director General (RD) & SS (Retd.), Ministry of Road Transport & Highways, New Delhi
38	Sinha, A.V.	Director General (RD) & SS (Retd.), Ministry of Road Transport & Highways, New Delhi
39	Singh, Ranjit	Additional Director General (Border), Central Public Works Department

Corresponding Members

1	Gajria, Maj. K.T.	ADG (Retd.), Military Engineer Services
2	Puri, S.K.	Director General Manager (RD) & SS (Retd.), Ministry of Road Transport & Highways, New Delhi
3	Ramana, K. Venkata	Chief General Mangaer (Technical), National Highway Authority of India, New Delhi
4	Saxena, R.K.	Superintending Engineer (Retd.), Ministry of Road Transport & Highways, New Delhi
5	Singh, Jaswant	Project Director, M/s Clairvoyant Engg. Consl. Pvt. Ltd.

Ex-Officio Members

1	President, Indian Roads Congress	(Joshi, C.P.), IE, Govt. of Maharashtra, Maharashtra State Road Development Projects
2	Honorary Treasurer, and Secretary General, Indian Road Congres	(Nirmal, S.K.), Additional Director General (Nodal), Ministry of Road Transport & Highways, New Delhi

INTRODUCTION

Considering the need for planning of expressways (greenfield as well as brownfield) to augment ever increasing demand for high speed corridors for faster movement of freight and passengers commensurate with growing economy of the Country, a Standard Manual of Specifications and Standards for Expressways was brought out by the Indian Roads Congress (IRC) in 2013 as a guidance for construction of fully access controlled highways. Being a new manual with limited exposure to experience in Expressways construction, the Manual was structured on the lines of the existing Manual of Specifications and Standards for Four and Six-laning of Highways published by IRC, with suitable provisions to cater for fully access controlled highways where entry and exit points are provided at pre-determined locations.

With experience gained in construction of more and more expressways and greenfield economic corridors by MoRTH and a few States, and massive network of Expressway being planned and constructed throughout the country, especially after mandate of Bharatmala Pariyojana, a need has been felt to review the provisions in the existing manual to suggest a robust expressway manual. Accordingly, the matter was referred to present G-1 Committee under the Convenorship of Shri B.N. Singh, DG(RD) & SS(Retd.), MoRTH to revise the manual by taking advantage of the experiences gained over the years in implementation of greenfield fully access controlled expressways. In this regard, a Sub group consisting of S/Shri M.P. Sharma, L.P. Padhy, Nirmaljit Singh, A.V. Sinha, Ashok Kumar, S.K. Nirmal and Ashok Bhasin were assigned with the task of reviewing and providing input for modification in the Manual based on the experience gained in construction of greenfield expressways during the intervening period. The sub group has recommended for elaborate revision in the current manual with sweeping changes in basic conceptualization of expressway. Some of the changes, among other suggested changes, are as under:

i) The lane configuration based on traffic and other considerations shall be initial over designed to rule out any capacity augmentation need during the service life, which may extend beyond the usual design life of 30 years,

ii) The lane configuration and facility planning should be finalized at initial stage itself and in no case, the planning of the expressway shall permit capacity augmentation during the service life, as it would be inefficient and unsafe for the following reasons; (a) addition of lanes during the service life of the expressway would lower the LOS during capacity augmentation, (b) it would be unsafe to undertake any construction in the midst of running traffic, (c) it would upset other facilities on the expressways such as ramps, interchanges, service areas, toll-plazas, etc. and necessitate their remodeling.

iii) The scope of the Manual should extend to all aspects of expressway project, i.e., planning, design, construction, maintenance and operation.

iv) The entire functional Right of Way (ROW) of the Expressway including additional acquisition for the ramps, interchanges, service areas, toll plazas, shall be fenced to totally prevent entry of pedestrians, slow moving vehicles and stray animals on to the Expressway.

v) A parallel low grade unsurfaced road beyond the Expressway fencing combined with an under/over pass at suitable interval shall be provided to avoid inconvenience to severed communities and properties owners.

vi) The overpass structure shall span the entire Expressway from the outer edge of the earthen shoulder of one carriageway to that of the other carriageway i,e. there shall be no pier in the median.

vii) The Authority should not bar the Concessionaire to use new/alternate material/ technology. The decision of use for appropriate material/technology will rests with the concessionaire subject to satisfactory compliance to the provisions thereof. No separate approval from the Authority is required for using material/Technology accredited by IRC or material/ technology for which international Codes, Standards, Specifications, Guidelines are available.

viii) The approach gradient to the grade separated structure shall not be steeper than 2.0 percent.

ix) It was recommended to introduce a detailed chapter on Operation and maintenance (Chapter 16) stipulating detailed output based operation and maintenance criteria. It was emphasized that the **Schedule K** of the Concession Agreement shall also be developed in line with the tolerance criteria specified in this section.

x) Closed Tolling system to be followed in which the vehicle entry shall be recorded by the FASTag readers installed on the entry ramp. A detailed chapter on Toll Plaza with emphasis on ETC infrastructure, ITS -based toll operation system (FASTag) etc. has been introduced.

The recommendations of the sub group and the corresponding draft was deliberated in a series of meetings. The G-1 Committee finally approved the draft document in its meeting held on 30th April 2022 and decided to submit the final draft to IRC for placing before the GSS Committee.

The Composition of G-1 Committee is as given below:

Singh, B. N. .....Convenor

Sarangi, D. .....Co-Convenor

Padhy, L.P. .....Member Secretary

Members

Nirmal, S.K. Pandey, R.K.

Kumar, Navin Kumar, Atul

Patelia, P.R.	Kumar, Sandeep
Meghwal, D.R.	Singh, Nirmaljit
Sinha, A.V.	Sharma, M.P.
Srivastava, A.K.	Kumar, Ashok
Pateriya, Dr. I.K.	Singh, V.K.
Sonawane, Prashant	Chandra, Nikesh
Goyal, J.K.	Chopra, Naresh
Asati, Manish	Kumar, M. Kishore
Jindal, S.C.	Gupta, Rahul

Corresponding Members

Dekate, Dr. M.N.	Gupta, D.P.
Bongirwar, P.L.	Lee, Aw Soon

The revised draft document was placed before the General Specification and Standards Committee (GSS) in its meeting held on 11.06.2022. The GSS Committee approved the revised document and recommended it for placing before EC/Council. The EC in its meeting held on 16.06.2022 approved the document for placing it before IRC Council. The IRC Council in its 223rd meeting held on 17.06.2022 at Shillong (Meghalaya) considered and recommended that views/suggestions of IRC Council be considered by an expert group under Chairmanship of Shri C.P. Joshi, President, IRC (List of Personnel given below) and finalise the draft document. Accordingly, an Expert Group was constituted by IRC under the chairmanship of Shri C.P. Joshi, President, IRC which in its meeting held on 28.08.2022 considered the suggestions/views of IRC Council and approved the draft document for printing.

The Personnel of Expert Group is given below:

Joshi, C.P.	Sharma, R.S.
Nirmal, S.K.	Shrivastava, A.K.
Singh, B.N.	Padhy, L.P.
Sarangi, D.	Meghwal, D.R.
Pandy, R.K.	Patelia, P.R.
Sinha, A.V.	Kannojia, Ashok
Sharan, G	Shelar, Santosh G,
Singh Nirmal Jit	

SECTION 1

GENERAL

1.1 Application

1.1.1 Expressways are meant for high-speed traffic movement, which benefit the individual users by reducing their travel time as well as the national economy by bringing efficiency in overall transportation. The speed of travel (and hence the travel time) on any road is not the free choice of the users, but depends upon both, the road infrastructure and the traffic flow condition. On expressways, both these conditions must be controlled. Safety is a major issue associated with high speed and that needs to be considered at every stage of the expressway, from inception to operation. This Manual is applicable for construction of Expressways through Public Private Partnership (PPP) mode. The Manual shall also be applicable for construction of Expressways on EPC mode. In case of EPC contracts, the terms 'Concessionaire' and 'Concession Agreement' shall be replaced by 'Contractor' and 'Contract Agreement' respectively.

1.1.2 The expressway project as planned, designed, constructed and operated has to deliver value, i.e., meet the expectations of the society at large, which would be possible only if time, quality, safety and environment are all taken care of at every stage of the project. A realistic timeline for design and construction has to be decided and maintained for construction, maintenance and operational activities, especially where these are critical to prevent accidents (e.g. by timely cautioning the users of adverse conditions) and save human life (e.g. by immediately rushing an accident victim to trauma center). As for quality, its ultimate test is 'fitness of purpose', however, the quality should span the inputs (not only material but also human), processes (not only mechanical but also human) and the products or outcomes. Similarly, safety must be built into every process and concern of users as well as non-users.

Expressway project will leave an impact on environment in more ways than one. The alignment may pass through sensitive land uses; land degradation is likely due to removal of vegetation, extraction of construction materials and scarring the landscape, waste of top soil, dumping of construction debris, oil and mix spillage; water pollution due to choking of water courses by debris, untreated effluent discharge into rivers, sourcing water from ground water reservoirs for construction in view of already polluted surface water sources; air pollution by increased GHG emission due to plant operation and traffic operation, increased particulate matters due to construction dust, increased noise level due to machine and traffic operation. All these adverse impacts have to be mitigated by restoring the landscape, noise and dust control, recycling of surface water, dust palliation, creation of carbon sinks, etc., as an integral part of the project.

This Manual shall apply to all Projects of fully access controlled multi-lane Expressways to be built on a new alignment (or Green Field Expressway). Where the Manual is to

be used for brownfield projects, the provisions of the Manual shall be suitably amended to meet the project or site specific requirements. The Manual sets the requirements of planning, standards, design, construction, maintenance, operation, safety and environmental safeguards to be fulfilled in delivery and operation of the Project [Name of the Project] under the Concession Agreement entered into between the Authority [Name of the Authority] and the Concessionaire [Name of the Concessionaire].

1.2 Scope

1.2.1 Generally, only fast moving (motorized) vehicles are allowed access to Expressways. They are inter-city Expressways located in open country outside the built-up area. The alignment may, however pass through isolated small stretches of built-up area as long as the character of the Expressway as a whole does not change. The Manual is not directly applicable to the design of Expressways in urban areas and in the hilly terrain. The Manual is predominantly for green-field expressways in Plain and Rolling terrain, which may have some sections of an existing highways or some urban sections included within the project scope of a specific project after upgradation to expressway standard, but is not meant for wholesale upgradation of an existing highway facility into an expressway.

1.2.2 The Authority shall decide the lane configuration based on traffic and other considerations (e.g., initial over-design to rule out any capacity augmentation need during the service life, which may extend beyond the usual design life of 30 years, or conversely, initial under-design to target a service life lower than the usual design life of 30 years)

Design life shall be 30 years and service life shall be the number of years from the base year when the design service volume exceeds the limit of LOS 'C'.

The Manual envisages a six-lane configuration for Expressways and all the facility planning be done for this configuration. In case, the Authority comes to the conclusion that a six-lane expressway would be grossly over or under design, the lane configuration could be changed to four or eight-lane respectively in the initial stage itself and do the facility planning accordingly. In no case, however, the planning of the expressway shall permit capacity augmentation during the service life, as it would be inefficient and unsafe for the following reasons; (a) addition of lanes during the service life of the expressway would lower the LOS during capacity augmentation, (b) it would be unsafe to undertake any construction in the midst of running traffic, (c) it would upset other facilities on the expressways such as ramps, interchanges, service areas, toll-plazas, etc. and necessitate their remodeling.

1.2.3 The scope of the Manual is not limited to construction and maintenance alone, but extends to all aspects of expressway project, i.e., planning, design, construction, maintenance and operation

1.2.4 The Manual recognizes that a number of agencies, governmental and non-governmental, would be involved in expressway development and operation and the Authority shall be responsible for inter-agency coordination under suitable arrangements, understanding, or contract.

1.3 Concessionaire's Responsibility

The Project Expressway and the project facilities shall conform to the requirements of design and specifications set out in this Manual, which are the minimum prescribed (for a six-lane Expressway). The project report and other information provided by the Authority[1] shall be used by the Concessionaire only for his own reference and for carrying out further investigations. The Concessionaire shall be solely responsible for undertaking all the necessary surveys, investigations and detailed designs with due diligence, and shall have no claim against the Authority for any loss, damage, risks, costs, liabilities or obligations arising out of or in relation to the project report and other information provided by the Authority, which would be used by Concessionaire only for his own reference.

1.4 Acceptable Codes, Standards, Guidelines and Technical Specifications

The Codes, Standards, Guidelines and Technical Specifications applicable for design and construction of project components are as follows:

i) Indian Roads Congress (IRC) Codes of Practice, Guidelines and Standards (Refer **Appendix-1**).

ii) Specifications for Road and Bridge Works issued by the Ministry of Road Transport & Highways (MoRTH) hereinafter referred to as MoRTH or Ministry's Specifications.

iii) Other standards referred under Clause 1.10 hereinunder

iv) MoRTH circular referred to in the Manual and any supplement issued with the bid document.

1.5 Priority of Documents

The Manual shall, in conjunction with other applicable technical standards, form part of the Concession Agreement as one of its Schedules [Name of the Schedule] and accordingly, shall be harmoniously construed with the Concession Agreement and the various other Schedules to the Agreement. Conflicts, if any, between the provisions of this Manual and other documents forming part of the Agreement shall be resolved as follows:

---

1 Authority / Government / Client

a) Between this Manual and the Agreement, the provisions of the Agreement shall prevail except otherwise mandatorily specified in the Manual.

b) Between this Manual and any other Schedule, the Schedule making the specific provision relating to the subject matter of conflict shall prevail over the one making a generic provision except otherwise specifically mentioned in the Manual; and

c) Between any two or more provisions of this Manual including the applicable technical standards forming part of this Manual

   i) Where specific options are provided in the Manual, these shall prevail over the generic or multiple options permitted in any technical standard

   ii) Where there are conflicts in Indian and foreign standards, the former shall prevail unless the Manual specifically permits the latter

   iii) Where there are conflicting provisions in two foreign standards, the one that is approved by the Authority shall be followed

   iv) Where different versions of any technical standards are available, the version that dates prior to 60 days before the bid due date shall prevail

1.6 Latest Version/Amendments

Latest version of the Codes, Standards, Specifications and Amendments thereto notified/ published at least 60 days before the last date of bid submission shall be considered applicable. For avoidance of doubt, if any specification/code comes into effect after 60 days prior to bid due date and the Concessionaire proposes to use (both during construction and O&M stage), may be allowed as per Para 1.10 and 1.11 of the Manual.

1.7 Terms Relating to Ministry of Road Transport and Highways

The terms 'Ministry of Surface Transport', 'Ministry of Shipping, Road Transport & Highways' and Ministry of Road Transport and Highways' or any successor to or substitute thereof shall be considered as synonymous.

1.8 Terms Denoting Independent Engineer

1.8.1 The terms 'Inspector' and 'Engineer' used in MoRTH Specifications shall be deemed to be substituted by the term "Independent Engineer", to the extent it is consistent with the provisions of the Concession Agreement and this Manual. The role of the Independent Engineer shall be as defined in the Concession Agreement.

1.8.2 In case of EPC contracts the term 'Independent Engineer' shall be replaced by 'Authority's Engineer' and the terms 'Concessionaire' and 'Concession Agreement' shall be replaced by 'Contractor' and 'Contract Agreement' respectively.

1.8.3 The role of Independent Engineer or the Authority's Engineer shall be as defined in the Concession or Contract Agreement as the case may be.

All actions shall be taken in accordance with the provisions of the Agreement and the standards set forth in this Manual.

1.9 Building Works

All items of building works shall conform to Central Public Works Department (CPWD) Specifications for building works and standards given in the National Building Code (NBC). To the extent specific provisions for building works are made in IRC/MoRTH Specifications, the same shall prevail over the CPWD/NBC provisions. For this purpose, building works shall be deemed to include toll plaza complex, road furniture, roadside facilities, landscape elements and/or any other works incidental to the building works.

1.10 Alternative Standards and Specifications

1.10.1 This Manual generally provides for design and construction as per Codes, Standards, Specifications, Guidelines, etc. as published by IRC, MoRTH and BIS for road and bridge works. The requirements stated in the Manual are the minimum.

1.10.2 Based on life cycle project cost comparison amongst the options using conventional material/ technologies & with the use of new/ alternative Material and Technology, the Authority at DPR stage, may assess that the new/alternative Material and Technology proposed is cost effective as well as environment friendly.

1.10.3 The cost of the project will be determined based on conventional material/ technologies or new/alternative Material and Technology which is most economical to the Authority.

1.10.4 The Authority will not bar the Concessionaire to use other new/alternate material/ technology. The decision of use for appropriate material/technology will rests with the concessionaire subject to satisfactory compliance to the provisions stipulated here under.

1.10.5 In case use of such new/alternate material/technology by the Concessionaire brings down the cost of construction/maintenance, provided it meets all other design / construction provisions as envisaged in the Agreement and stipulated in the Codes, Standards, Specifications, Guidelines etc. specified under **Schedule D**, the Authority shall not revise the contract price nor ask the Concessionaire to transfer the cost reduction benefit to the Authority.

1.10.6 For removal of doubt it is clarified that the use of Cement Treated Base (CTB), Cement Treated Sub-base (CTSB, Waste Plastic, Geo-Synthetics, Recycling, Fly-ash, modified Bitumen (CRMB, Polymer modified, Natural Rubber), Soil stabilization, etc. in highway construction are covered under IRC Guidelines. These items are not to be treated as new / alternate material / technology. IRC has also accredited new materials/techniques/ equipment/products. These may also be used as per the relevant Codes & Guidelines.

1.10.7 For removal of doubt it is clarified that the material/ technology for which Codes, Standards, Specifications, Guidelines etc. of IRC, MoRTH, AASHTO, ASTM, Euro Code and National Standards of United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, the Netherlands, Spain, Australia, New Zealand, Japan and South Africa are available shall not be treated as new/ alternate material/technology and, as such, Defects Liability Period (DLP) of projects using such material/technology shall not fall into the category corresponding to new material/technology. Hence the defect liability period will be at par with conventional/ flexible pavement.

1.10.8 Any new alternate, material & technology that has been accredited by IRC, and falling under **IRC:SP:89 (Part II)**, will not require further accreditation, and will henceforth fall under approved, alternate, material and technologies. For such approved, alternate material and technologies, the Defect Liability Period shall be at par with conventional / flexible pavement.

1.10.9 No separate approval from the Authority is required for using material/Technology covered in standards mentioned in Para 1.10.6, 1.10.7 and 1.10.8 above.

1.10.10 Where the Concessionaire intends to use an alternative to the prescribed standards & guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

i) He shall demonstrate that the proposed alternative conforms to any of the following International Standards, Codes of Practice, Specifications, Guidelines, etc.

   a) American Association of State Highway and Transportation Officials (AASHTO)

   b) American Society for Testing of Materials (ASTM)

   c) Euro Codes

   d) National Standards of any of the following countries:

United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, the Netherlands, Spain, Australia, New Zealand, Japan and South Africa. More particularly, Highway Capacity Manual of Transportation Research Board, USA (version 2010 and later) can be applicable for design and construction of project components.

1.10.11 In case the Concessionaire intends to use any alternative material, technology / method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar projects (similar in category of road, traffic and climatic conditions) as the Project Expressway, he would be permitted its use on certification by the owners of such similar projects regarding the continued successful performance of such materials,

technologies, methods, procedures or processes for the design life of the project. Such a certification shall be supported with details of critical performance parameters

All such proposals shall be submitted by the Concessionaire to the Independent Engineer together with certification and details mentioned in Para 1.10. Usage in Indian condition shall not be insisted by the Independent Engineer for the Material Technology if certification by owners of similar projects regarding the continued successful performance of such materials are confirmed. The Concessionaire will however be required to submit all quality assurance and quality control documents and demonstrate to the satisfaction of Independent Engineer satisfactory performance of the pavement or structure using such material or technology. Authority may seek performance of the use of such material and technology through appropriate mechanism. Suitable Defects Liability Period of such projects shall be finalized prior to approval depending on specific technologies varying from 5 to 10 years

Such a certification shall be supported with details of critical performance parameters.

1.11 Procedure for use of Alternative Standards & Specifications

1.11.1 If the use of alternative material / technology is not specifically covered in the Indian or International Standards as mentioned above in Para 1.10, the concessionaire would be permitted its use in accordance with Para 1.10 above

1.11.2 The Independent Engineer shall approve the design and drawing of all the new / alternate Materials proposed by Concessionaire/Contractor for which international standards are available. In case, the Independent Engineer is of the opinion that the proposal submitted by the Concessionaire is not in conformity with any of the International Standards or Codes or evidence by successful performance, then he will record his reasons and convey the same to the Concessionaire for compliance. In any case non approval or rejection by the Independent Engineer does not give any right to the Concessionaire for claims and / or disputes, if any. A record shall be kept by the Independent Engineer, of non-compliance, if any, by the Concessionaire. adverse consequences, if any arising from adoption of any such alternative proposals shall be treated as "Concessionaire Default" and shall be dealt in accordance with the provisions of the Concession Agreement.

1.11.3 It is important that all the scope of work is clearly defined in the relevant schedules to avoid disputes during implementation. Inconsistencies, if any, in the defined scope of work as well as consequent change of scope must be firmly decided within six months of start of work and once resolved such decisions normally shall not be opened for review.

1.11.4 Provisions under **Para 1.10 and 1.11** above shall also be applicable for EPC projects unless specified otherwise in the Agreement.

1.12 Guidelines for Preparing Schedules of the Concession Agreement

Certain paras (full or part) in Sections 1 to 16 of this Manual refer to the Schedules of the Concession Agreement. While finalizing the feasibility/project report for the Project Expressway, and the scope of the project, each of these paras should be carefully examined and addressed by the Authority with a view to making appropriate provisions in the Schedules of the Concession Agreement. **(A list of the Paras that refer to such schedules has been provided at Appendix-2 for ready reference).**

1.13 Responsibilities of the Entities Concerned with the Project

The Authority shall, with the assistance of a qualified Consultant, have a Project Report prepared. The Authority shall approve the Project Report and the Bid Documents shall be based on such approved project report. The Project Report shall contain, inter alia, the alignment on which the Project Expressway has to be constructed, the location, layout, typical cross sections of all the Project elements, which will define the scope of the Project, and the limits of land to be acquired within which the Project Expressway with all its elements have to be accommodated and the type of land use across the alignment. The guidelines for design of the Expressway Projects and preparing the Report are at **Enclosure – 1** which shall be followed for project preparation purpose.

The Detailed Project Report shall be shared with the bidders of the Project to help them generally understand the requirements of the Project and prepare a realistic bid with the disclaimer that this shall not form part of the Agreement and the basis of any dispute or claim. The Concessionaire or the Contractor, as the case may be, shall through its own efforts and to its own satisfaction verify, validate and supplement the information contained in the Project Report. The Authority's Consultant shall follow-the standards set forth in this Manual in preparation of the Report and the Schedules based thereon.

1.14 General Considerations for Planning, Design and Construction

The Project Expressway shall be planned as a "Fully Access Controlled Highway" where entry to and exit from the Expressway shall be provided only at pre-determined locations through properly designed entry/exit ramps and/or from interchanges. In doing so, the Concessionaire shall take measures to overcome the physical and operational constraints and plan, design and construct the Project Expressway using appropriate methods, management techniques and technologies. General considerations shall, without being limited to, be as mentioned in the guidelines in this para above (**Enclosure – 1**).

1.15 Planning

Planning shall involve (i) Facility Planning, (ii) Access Control requirements (iii) Logistic of movement of intervening teams (iv) Toll Plazas (v) ITS infrastructure (vi) Traffic Management (vii) Incident Management (viii) Traffic Control Centre Operation (ix) Land efficiency and (x) Standard Operating Procedures and Protocol.

1.15.1 *Facility Planning (Layout & Design Features)*

The layout & design features are prescribed in Section – 2 (Geometric Design & General Features).

1.15.2 *Other Planning Aspects*

Other planning aspects to be considered are as under:

1.15.2.1 Access Control Measures

The Project Expressway shall be planned as a "fully access controlled highway" fulfilling the following essential requirements

i) Expressway Use only by motorized vehicles

The Project Expressway shall be used exclusively by motorized vehicles. Pedestrians, cyclists and non-motorized vehicles shall not be permitted on the expressway No facilities targeting motor cycle/two wheeler, tractor, three wheelers and non-motorized vehicles categories on road shall be planned on the expressway.

ii) Access only through ramps

There shall be no entry of vehicles into or exit from the Project Expressway except through properly designed ramps. The design of ramps shall be an integral part of the design of the Project Expressway.

iii) Ramps only at Interchanges and specified locations

All roads lower in the hierarchy of roads than expressways (i.e., National Highways. State Highway, Major District Roads, Other District Roads, Access Roads, Village Roads) shall either run parallel to (i.e., without intersecting) or pass over the expressway (i.e., grade separated) without any connecting links (or ramps) between such roads and the Expressway, except in the following situations where these are to be specifically planned:

a) Interchange Ramps and Loops

Intersection with important roads (e.g., NHs/SHs) where movements in all directions are planned to and from the expressway and the intersecting roads.

b) Left-in and Left-out Ramps

Where limited movements of 'Left-in' entry to and 'left-out' exit from the expressway are planned to connect an existing road/ road network with the Expressway.

iv) Ramp Terminal only at a high category road

One of the two terminals of the Ramps shall connect to a Road, which is usually one rank lower in the hierarchy of roads, and exceptionally two ranks lower. In other words, this terminal shall be on an NH or an SH or an Urban Arterial and only exceptionally on an MDR or ODR, and in no case on an Access Road.

v) No parallel service Roads

There shall be no parallel Service Roads within the functional ROW of the Expressway that can act as an Access Road for the adjoining properties or form part of a local Road Network, but simultaneously provide access to a highway through short connecting links. All Access Roads, whether existing or planned, shall be outside the functional ROW limit of the Expressway

vi) Complete fencing for isolating non-Expressway Users

The entire functional Right of Way (ROW) of the Expressway including additional acquisition for the ramps, interchanges, service areas, toll plazas, shall be fenced to totally prevent entry of pedestrians, slow moving vehicles and stray animals on to the Expressway.

vii) Passages for severed communities and properties

Where property or community severance is necessitated due to ROW acquisition for the Project Expressway suitable passage for pedestrians and vehicles across the Project Highway shall be provided either under or over the Expressway. A parallel low grade unsurfaced road beyond the Expressway fencing combined with an under/ over pass at suitable interval shall be provided where such severance is likely to cause inconvenience to the property owners.

viii) No conflicting right or U turn

The Project Expressway shall be a free-flowing facility without any conflicting movements and hence without signal controls. Any vehicle that enters the Expressway shall continue to travel in the same direction (i.e., straight direction) and cannot turn left or right except at the ramps, where it will be permitted only a left turn. The 'main line' expressway traffic can take a right turn either through a loop ramp, where it is provided (as on an interchange), or through an 'off-line' right turning facility after exiting the expressway through a left-out exit ramp. This would mean that there shall be no median opening between any successive ramps causing conflict with the on-coming traffic needing to be controlled by signals. There shall, however, be a collapsible or movable median barrier at 5 km interval, which shall remain in 'locked' mode, except in emergencies, when it will be 'opened' only for emergency intervention.

ix) No contra flow movement except in emergencies:

Expressway management agency shall ensure that there is no contra flow movement by any vehicle on any ramp and main-line expressway. This rule shall apply to the expressway operation and maintenance teams as well. The exception shall be only for emergency vehicles, which can be permitted contraflow movements that should be accompanied with lane/ carriageway closure.

1.15.2.2 Logistics of Movements of intervening teams

The teams that are authorized to intervene on the expressway for operation, maintenance, road clearance and emergencies shall have to move quickly from their respective bases to any point on the expressway on either carriageway. The location of their bases is an important consideration. These bases shall be so located that they get immediate access to either side carriageway. Their return from the intervention site along the same carriageway is not possible as any contraflow movement is not permissible. They will have to move on the same carriageway in the direction of traffic. They will also not be permitted to take U-turn from the next emergency median opening as that would not be permitted to use these for non-emergency purposes. Under these circumstances the options available for their return are limited.

One option is that they take the next interchange to exit the expressway, after taking the exit, enter the opposite side carriageway, move on that carriageway and take another U-turn from the next interchange to return to the same carriageway. This would involve minimum 25 km and maximum 50 km of travel (assuming interchange spacing of 25 km). A second option could be to take the next exit and take the frontal road to finally take an entry ramp to come on to the expressway. This option has a chance of getting caught in the frontal road traffic jam besides moving on a road on which the Authority has no jurisdiction for a considerable length. A third option could be to have a parallel single lane road on either side carriageway with circulation under an overpass structure.

The location of the O&M base, detailing of the personnel, limitation of the movement options and the relative capability of the various infrastructure options to facilitate a quick movement have all to be considered in the expressway planning.

1.15.2.3 Toll plazas

Tolling system to be followed shall be a closed system in which the vehicle entry shall be recorded by the FASTag readers installed on the entry ramp and the users' accounts shall be debited after detecting its exit on the exit ramp for the length of travel between the entry and exit.

In the exceptional event of open toll system, continuing for any reason, and the tolling continuing to be operated from toll plazas for a fixed length of travel regardless of actual travel length, the first consideration in deciding the toll plaza location shall be to weigh

the relative advantages and disadvantages of an 'off-line' and 'main-line' toll plaza. An 'off-line' toll plaza has the distinct advantage of delaying only those vehicles at the toll plaza, which take exit from the interchange while all other vehicles on the main line suffer no delay. In contrast, a 'main-line' toll plaza causes delay to the entire main-line traffic. The former would, therefore, be more efficient. The disadvantages on the other hand are (a) the 'off-line' toll plaza will have to be located on a road on which the Authority may not have any jurisdiction or has to form new alternative links to the local network alongside toll plaza, and (b) in order to control all entries and exits at one location, there is no choice left of the interchange layout except trumpet layout.

1.15.2.4 ITS infrastructure

The expressway operation shall be ITS enabled, which in simple terms would mean to provide as many user services as possible in the operation. The user services to be provided on the expressway, to start with, shall be road and traffic information, traffic management, and toll operations. ITS -based toll operation system (FASTag) already exists. Two other ITS based services are available in the country, the driver licensing (Sarathi) and vehicle registration (Vahan). All these services have to be integrated on ITS platform. In future other services like multi-modal transportation would have to be added.

The first step is about deciding the ITS Architecture or the manner in which various system components (e.g., traveler, centers, vehicle and field) providing user services are connected within themselves and with one another, the 'communication layer' being at the core of such inter and intra connections. There are two ways in which this architecture has evolved: one in which the communication system is considered technology neutral and the user has the flexibility in making the technology choice subject to ensuring 'inter-changeability' and 'inter-operability' of the communication system components in nation-wide application (National ITS Architecture of the USA); and the other in which the components of the communication system follow a certain standard such as IEEE standards (Institute of Electrical and Electronics Engineers) and all user services are delivered using standard components developed following a certain agreed communication protocol like OSI or Open System Interconnection (the FRAME Architecture followed in Europe and similar Architecture in Japan). Without going into the debate of which Architecture to be followed, this Manual recommends that the ITS platform should be one that ensures interchangeability, inter-operability, and vendor neutrality through use of standard components and communication protocol.

The other issue to be decided is the Communication Technology to be used: wired, wireless or cloud-based wireless. This Manual recommends a detailed study by the Consultant of the Authority to suggest a communication system technology and communication system layout for the project.

The ITS application shall use the field devices (like sensors and VMS displays). Notwithstanding the use of standard components, the technology of field sensors (e.g.,

inductive loop, microwave, infra-red, video image processing, etc.) and VMS displays shall also be recommended by the Authority's Consultant after considering the relative merits and demerits.

ITS infrastructure planning, layout and infrastructure shall be recommended by the Authority's consultant.

1.15.2.5 Traffic Management

The functions of Traffic Management shall be as follows:

i) To keep a complete vigil on the use of expressway assets (ramps, interchanges, service areas, etc.) and whether these are in good serviceable condition (e.g., road signs, markings, traffic lights, etc.) and not misused (e.g., by ingress into the fenced area, contraflow movements, unauthorized parking, etc.)

ii) To detect incidents on the expressway, ramp and interchanges (e.g., debris dump, presence of disabled vehicles, crashes) and direct the concerned team to intervene and clear the expressway

iii) To monitor the traffic flow on the expressway and the ramps and using the traffic management algorithms evaluate the operating condition (normal flow, building up of congestion, congestion and break down flow, etc.),

iv) To inform the users the operating conditions (such as bad weather, building up of congestion, congestion, lane/carriageway closures, etc.) and the quality of their travel (e.g., time to destination, operating speed on the expressway, etc.)

v) To guide the users into taking appropriate action (e.g., slow down, unsafe headway, gap acceptance, take next exit, entry closed, etc.)

vi) To alert the concerned teams to intervene (e.g., close a ramp, clear the carriageway, regulate the entry, mobilize the emergency services)

vii) To get feedback from the field and update the information to the users (e.g., road clear now, crash site restored, lanes open)

Traffic management algorithm shall be developed by the Authority' consultant using the fundamental traffic engineering equations (on speed, flow, density, etc.) and capacity analysis in accordance with procedures recommended in the Highway Capacity Manual of the USA. The raw traffic data shall be sensor specific. Where video images from field are used for determining speed, flow, etc., a suitable Video Imaging Processing (VIP) algorithm shall be used for analysis. The traffic management software developed to predict the flow characteristics shall be validated using other methods including manual methods to calibrate the traffic flow model and validated by using it on actual situation.

The Authority's Consultant shall also suggest the type and technology of the field devices (in-field sensors and VMS displays). The recommendation shall be made on the basis of the capabilities of the controllers of the field devices (the built-in system electronics), compatibility with OSI data communication protocol, conformity of the sensor to the approved international standards, inter-changeability (i.e., replacing sensor of one make by another), interoperability (i.e., the capability to keep the system functioning with such change and replacement), and vendor neutrality.

1.15.2.6 Incident Management

Incident management shall involve two types of interventions, normal intervention, and emergency intervention. The normal intervention shall be a routine function such as detection of any incident (i.e., occurrence of an event) by regular patrolling, information from users, images captured on videos, complaint from expressway users and observation by inspection teams. The incident could be a breach, a damage, a broken crash barrier, debris on carriageway/shoulder, disabled vehicle on carriageway, closure of a lane/ carriageway, teams working in the field, etc. The normal incident management functions can be accomplished by the regular O&M teams except where carriageway clearance involves heavy equipment like cranes, earth movers, etc. such as road clearance post-crash or post landslides or rock fall. To deal with such situations, arrangements have to be made with well-equipped service providers who can intervene on call.

The emergency management during crashes and fire shall involve, police, fire, trauma centres and at times even road clearing agencies. The interventions have to be quick and, if necessary, by closing the lane or whole carriageway, stopping the traffic, allowing contraflow of emergency vehicle, use of emergency median opening. All vehicles have to stop and give way to the fleet of emergency vehicles once an emergency is announced by the TMC either on PA system, or dedicated radio, or on VMS display. Similarly all traffic restrictions shall cease when an accident victim is transported to the nearest trauma center.

1.15.2.7 Traffic Control Centre

Traffic Control Centre shall be the nerve center of the expressway operation and management, which shall be the cooperative effort of different agencies as indicated in Clause 1.2.4 above. Depending upon the availability of space and readiness of various agencies involved the entire team can be located in the TMC complex or they may be dispersed at other places and be in 24X7 contact with one another electronically. The minimum facility at the Centre shall be for housing a Traffic Management Team for keeping an eye on the infrastructure and traffic in real time, analysing the data and taking management decisions and the Police team for traffic control for enforcing the rules.

Traffic Management Centre shall have an high speed Ethernet from which its in-house devices shall be connected to the field sensors and the field display units. It shall access

the field data and the processing algorithms from cloud-based servers and analyse the data to make various traffic management decisions and transmit the decisions as concern the users on the Variable Message Signs. The Control Room's in-house devices shall include a video wall on which the images from a number of locations can be viewed simultaneously. The Control Room functions shall be jointly managed round the clock by the Traffic Management and the Police Teams.

Traffic Control Centre shall pass on the instructions/advisories to the relevant teams to act within a time frame and in a manner as decided in the agreed protocol and standard operating procedure. The teams shall mobilise, intervene, give feedback to the Control Room, which will update the information on the field display units.

1.15.2.8 Traffic Management Centre Operation

Traffic Management Centres' operation apart from what has already been stated shall be

i) To manage the logistics by suitably stationing in the field the teams ready for intervention and giving instructions to that team, which can reach an incident site in the least possible time

ii) To keep other teams on alert or stand by

iii) To respond to the requests of the intervening field teams for more help by way of traffic management intervention (e.g. closure or diversion), calling an emergency by acting on such requests

iv) To alert and instruct all organisations dealing with emergencies such as calling ambulance, fire or police to intervene, alerting the trauma centre to be in readiness to receive a serious crash victim

v) To monitor the intervention and respond to the feedback information of completion of an operation

vi) To manage inter-agency coordination and send instructions/advisories to be acted upon by the teams detailed by various agencies in accordance with the agreed protocol and SOP

vii) A minimum of 100 Sqm plinth area building shall be provided for operation purpose.

1.15.2.9 Standard Operating Procedure and Protocol

SOP shall involve identifying the actions, selecting the person/ agency primarily responsible to deal with those actions, the time frame of the actions, other agencies that will have to be coordinated with or taken on board (secondary responsibility), the extent of involvement of the secondary agency, who will monitor and supervise those actions (supervision responsibility), what will constitute accomplishment of those

actions and who decides (approval responsibility), who will deal with public feedbacks and complaints (adjudicating authority). For example, traffic management is the primary responsibility of the person monitoring the traffic and the secondary responsibility of the police personnel sitting on the traffic management console. The roles will reverse in case a violation is detected, then the police will have the primary responsibility and traffic monitors will be the secondary responsibility.

Protocol shall involve the manner in which inter-agency or inter-team interaction shall be carried and shall be concerned with who initiates an action and who responds (e.g., traffic management team informs of an incident and the field team responds), what will constitute valid action (e.g. informing after the specified time limit shall not be a valid action) or response, how the supervision agency will respond if action or response is not adequate (e.g. informing the superiors in the hierarchy), how and when higher level functionaries have to respond if things including inter-team coordination is not proper or adequate.

The Authority shall draw up the SOP and the protocol.

1.16 Design

1.16.1 The design shall be done as discussed in Para 1.13 and Para 1.15 of this Manual

1.17 Definitions and Interpretation

1.17.1 Unless specified otherwise in this Manual, the definitions contained in the Concession Agreement shall apply.

1.17.2 Grade separated structures

i) The structures through which the traffic flows at different levels are called grade separated structures.

ii) A grade separated structure which is provided for crossing of vehicles under the Project Expressway is called as Vehicular Underpass (VUP).

iii) A grade separated structure which is provided for crossing of vehicles over the Project Expressway is called as Vehicular Overpass (VOP).

iv) Flyover is synonymous to VUP/VOP.

v) A structure provided above the Project Expressway for crossing of pedestrians is called Foot Over Bridge(FOB)

vi) A structure provided over the railway lines to carry the Project Expressway is called Road Over Bridge (ROB).

vii) A structure provided below the railway lines to carry the Project Expressway is called Road Under Bridge (RUB).

Enclosure – 1
(refer, Para 1.13)

Guidelines for Design of the Expressway Projects and preparing the Report by the Consultant

A. General Requirements

i) The Authority's Consultant shall carry out (a) studies and analyses for planning of the Project Expressway and the facilities, (b) recommend the alignment of the Project Expressway, the location and layout of the facilities, (c) develop the plan for the Right of Way acquisition for the Expressway and the facilities, (d) recommend an ITS Architecture with national perspective, (e) recommend the hardware for road side devices (sensors, cameras, VMS) and the required capabilities of their built-in electronics, (f) recommend an appropriate communication system for two-way data transfer (Field to Centre), which can be upscaled to Centre to Centre (g) develop a traffic management algorithm to calculate traffic flow parameters, (h) recommend the layout and equipment for Traffic Control Centre, (i) draft an MOU and SOP for inter-agency coordination.

ii) The outcome of the studies, analyses and recommendations shall be compiled in the form of a Report and submitted to the Authority, which may accept it with or without any changes that the Authority in its sole discretion deems fit. Thereafter, action as follows shall be taken

a) The Authority shall ask the Consultant to prepare and submit the land plan schedule for land acquisition

b) The Authority shall ask the Consultant to prepare the project specific Schedules (Schedules A, B, C, D and K)

c) Concurrently the Authority shall initiate action for land acquisition.

d) The Authority shall initiate action for signing of the MOU with different agencies

iii) In preparing the Project Report the Consultant shall aim at fulfilling all the requirements of this Manual and at the same time fulfil the Specific Requirements as described in para 2 below.

B. Specific Requirements

I Preliminary Expressway Alignment and location of facilities

i) The base plan for preparing the Preliminary Alignment Plan shall be 'orthographically projected' (i.e. in the normal map projection mode) satellite images in 1:50000 scale, having 'swathe' (i.e., the width of the ground covered by the image) of 70 km and horizontal 'resolution'

of 1 m, which shall be procured from Indian Space Research Organisation (ISRO). The images shall contain all the necessary overlays, which can show all the geo-referenced ground features, such as terrain, political boundaries, land use, land cover, transport network, soil cover, forest cover, water bodies, geological features, etc.

ii) The Expressway Alignment shall be drawn from this base plan using an appropriate image processing software on Geographic Information System (GIS) platform. The image files procured from ISRO shall be converted into 'shape' files in GIS format, which shall then be converted into Computer-Aided Design (CAD) compatible 'drawing' files. The alignment plan shall be generated from these drawing files.

iii) The alignment shall skirt all existing and proposed traffic generating land uses from which traffic can be drawn on to the Expressway by providing short spurs (not part of this Project, but the identification of the potential access points necessary for planning ramps and interchanges). Future traffic from planned land use developments (e.g., residential, commercial, industrial, etc.) and transfer facilities (e.g. transport park, container depots, special economic zones) shall also be similarly considered as the potential user of the Expressway.

iv) The alignment shall avoid sensitive land uses, such as built-up, forest, wild life habitats, wet lands and any statutorily protected areas

v) The access to the Expressway shall be planned from the existing road network. The general rule shall be that access shall be provided from roads, which are one level below in the hierarchy of roads, i.e., National Highways, State Highways and Urban Arterials. In exceptional situation (e.g., where higher category roads are not available within reasonable distance, say 10km and there is considerable access demand), access can be provided from Collector-Distributor (CD) Roads after upgrading them locally.

vi) Interchanges shall generally be provided at 25 km interval even if there is no existing road at present. The Authority shall construct the structure and the ramps within the Right of Way and the State Government shall build the connecting road beyond the Expressway ROW.

(vii) Toll Plaza shall be off the main-line Expressway. It can be combined with an Interchange and Traffic Control Centre. Service Area shall be provided at 50km interval and located at least 5km away from either side of an Interchange and Toll Plaza. The location of all the facilities shall be marked on the Preliminary Alignment Plan.

II Traffic Modelling

i) An estimate of traffic that will use each of the Expressway sections and the ramps shall be made for their design. Since no historical traffic data would be available for a green field Expressway, traffic modelling shall be done using an appropriate Land use and Transport Planning Model (LUTP), which shall be capable of modelling trip rates, trip generation and attraction, trip assignment, disaggregating the trips into vehicular flows, loading the flows on to the network and estimating the link volumes and their capacities.

ii) The volume on the links joining the Expressway through a Ramp shall be the Ramp volume. The volume on the main line expressway at any point down-stream of the ramp shall be the ramp volume plus the Expressway volume upstream of the ramp net of the volume exiting through the immediate upstream ramp.

iii) An LUTP model would require enormous amount of input data (such as existing and planned land use, trip rate, origin and destination, network configuration, etc.). Some of these data may be available with the State's Planning Authorities (e.g., network configuration) while others (e.g., Origin and Destination) has to be collected by field surveys. The Consultant shall collect data from authentic sources and conduct all the required surveys.

iv) Base year traffic volume shall be projected for the end-of the service life (i.e., service without any capacity augmentation need), which shall be 30 years. Minimum base year traffic shall be provided in Schedule B which shall be binding on the Concessionaire

III Capacity Analysis

i) Capacity Analysis of the main-line Expressway, Ramps, Ramp Terminals, Interchanges, weaving sections, and Merge/ Diverge Areas shall be done using Highway Capacity Manual (HCM 2010 or later version) procedure. The 'end of the Service' level of service (LOS) shall not be lower than LOS C for any of the above facilities. Simultaneously, the objective of the analysis shall be to ensure that the same LOS as prevails on the main-line Expressway is consistently maintained at all other locations (i.e., ramps, merge/diverge areas, etc.).

ii) In case the analysis shows that the ramps, ramp terminals, weaving sections and merge/ diverge areas are 'under capacity' (i.e., are likely to have inferior LOS than that on the main-line Expressway at any point in time) due to any reason (e.g., high ramp volume, platooned entry/ exit, under capacity link road upstream/downstream of the entry/exit ramp terminal, presence of signalized intersections on link roads close to the ramp terminals, etc.), this will give rise to unacceptable operating conditions (e.g., congestion, queues, turbulent flow, breakdown flow, unsafe maneuvers by drivers). Based on the analysis, remedial measures shall be suggested in the design, which, depending upon the prevailing situation, could be to remodel the link roads, staggered entry/exit, auxiliary speed change lanes, ramp metering, etc., as appropriate.

iii) Main-line Expressway in this Manual is proposed to have a six-lane dual carriageway. In case the analysis reveals that the 'end of service' LOS would cross the threshold of the limiting LOS C, the initial design itself shall be for an eight lane Expressway. The provisions of this Manual shall be changed *mutatis mutandis*.

IV Detailed alignment and layout of facilities

i) Detailed Alignment Plan, Longitudinal Section, Cross Section shall be prepared in 1:10000 scale by conducting detailed topographic survey along the Preliminary alignment and fitting in the geometry designed as per the provisions of this Manual. Detailed Layout Plan of all the facilities shall be prepared in the same scale, geo-referenced and superimposed on the detailed alignment plan and L-section.

ii) No direct entry to or exit from the main-line expressway to or from a facility (ramp/ramp terminal and service area) shall be permitted. All entry/exit shall be through an auxiliary lane the length of which shall be designed for the speed differential of the main-line expressway and the facility.

iii) Geometry of the ramp terminals shall be designed as per the recommendations in the AASHTO Green Book (A Policy on GEOMETRIC DESIGN of HIGHWAYS and STREETS 2001).

V Main-line Expressway

i) Main-line Expressway shall be formed on embankment maintaining minimum clearance above ground/HFL as specified in IRC 37. The embankment slope shall be 4H:1V or flatter.

ii) Main-line Expressway cross section shall have 2x3 lane carriageway, depressed median, paved shoulder at the edge of the carriageway, shyness on the median side, earthen shoulders on either side, unlined embankment drain beyond the toe of the embankment, and lined ditch drain in the middle of the median.

iii) Pavement of the main-line carriageway and paved shoulders shall be flexible/rigid as decided by the Authority. Flexible pavement shall be Perpetual Pavement designed as per IRC 37. Rigid Pavement shall be designed as per IRC 58.

iv) Cross sectional elements of the Expressway are shown in **Fig.2.1(a), 2.1(b)** and **2.1(c)**. The design standards are given in **Section-2**.

VI Entry/Exit left-in-left-out Ramps and Ramp Terminals

i) Where there is demand for access from a road link of the State Road network, which could be a Frontal Road or Access Road serving a large community, left-in-left-out entry/exit ramps shall be provided. Capacity of the Frontal/Access Road and the space availability to remodel it shall be a precondition for locating a Ramp Terminal with proper geometry. At the exit, both left and right movement shall be enabled. Similarly, entry for traffic from both directions on the Access/Frontal Road shall be enabled. The Access/ Frontal Road shall be remodeled with the cooperation of the authority owning the road. As a part of remodeling, existing signals, if any, in the close vicinity of the Ramp Terminals shall be removed/ relocated so as not to give rise to a tail back of the exiting traffic on the exit ramp and platooned entry of vehicles on the entry ramp.

ii) These ramps shall not be spaced closer than 2km. Ramp terminal geometry shall be as recommended in the AASHTO Green Book.

iii) Ramps shall usually be two lane with paved shoulder and all entry and exit to and from the main-line Expressway shall be through an Auxiliary Lane. Where the ramp width is more than one lane, the lane drop and lack of lane balance situation will arise even if one Auxiliary Lane is provided. In situations like this, multi-lane entry/ exit shall be staggered with one lane entry/exit at a time to maintain lane balance and avoid lane drop.

iv) Sufficient weaving length as per AASHTO Green Book shall be provided upstream of the Exit Ramp to enable the traffic intending to take exit to change lane, weave and entre the Auxiliary Lane, and similarly downstream of the Entry Ramp.

v) Gore Area at the exit shall be treated as per recommendations in the AASHTO Green Book and MUTCD. Gore area shall have chevron marking.

VII Interchanges with Ramps and loop ramps and Ramp Terminals:

i) The requirements of ramps in terms of lane balance, lane drop, auxiliary lanes as described above shall apply to the Ramps including Loop Ramps of Interchanges also. In addition, the geometry of the loop is important for which guidance in the AASHTO Green Book shall be followed.

ii) Out of the various standard interchange layouts (Diamond, Cloverleaf, Trumpet, Dumb-Bell, etc.), choice has to be made on the basis of land and operational efficiency. A land-efficient Interchange would be one that can accommodate other facilities like Toll Plaza, Traffic Control Centre, Parking of Maintenance and Operation vehicles, etc., within the Interchange complex avoiding the necessity of separate land for them. The operational efficiency requirement would dictate that (i) all possible movements (left, straight and right) from all intersecting arms of the Interchange are provided for, (ii) there is no merging and weaving traffic on the ramps including loop ramps, and (iii) the maintenance and operation personnel and crew stationed at the Interchange Complex can easily access the Expressway in both directions.

Where a Trumpet layout is chosen, it should be borne in mind that a standard trumpet layout can provide only six conflict free movement on three approach arms, and the remaining six (assuming a cross road configuration of intersecting roads) have to be provided by providing additional structures and remodeling/ realigning the remaining approach arm.

VIII Exit Numbering

Exit numbering signs shall be placed in advance of the exit. There should be a minimum of 3 signs marking each exit; an advance guide sign, an exit direction sign, and a gore exit sign. Exit number tabs consists of a white message (200 mm text and 400 mm digit height) on a blue background, and shall be attached to advance guide or exit directional sign. Exit gore signs used in exit numbering shall consist of a white message (250 mm text and 300 mm digit height) on a green background.

IX Diverge Areas

i) Diverge Areas shall be so designed that there is no breakdown flow (stop start condition) or drop in LOS ahead of diverging traffic for any reason, such as lane change and weaving ahead of the exit (unacceptable and unsafe maneuvers), no separate lane for exit making the left-most lane unavailable for through traffic (lane drop), crowding of the left-most lane(s) by exiting vehicles compelling the through vehicles to virtually stop and choose a less crowded lane (break down flow), increased density and reduced speed at the diverge area (drop in LOS), clogging of exit ramps due to downstream congestion on the exit ramp and build-up of queues on the main-line expressway (jammed exit), etc.

ii) Diverge area design shall, therefore, provide exit through an Auxiliary Lane (exclusive Exit Lane) so that all the lanes on the main line remain fully functional. The length of the Auxiliary

Lane shall be sufficient to store the vehicles if there is congestion on the exit ramps. Sufficient weaving length shall be provided ahead of the start of the Auxiliary Lane so that all lane change and weaving maneuvers are completed ahead of the exit.

X Merge Areas

i) Merge Areas shall be so designed that there is no turbulence in the traffic flow downstream of the merge area for any reason such as due to platooned entry of vehicles forcing the upstream vehicles to slow down or make emergency maneuvers, poor judgement of available gaps or ambitious gap acceptance, heavy main-line flow affording no or very small gap, direct entry to the main-line Expressway without any provision of Auxiliary Lane and/or, if provided, its length being inadequate, heavy entry flow demand even if the main-line flow is normal.

ii) Merge Area design shall, therefore, provide for entry only through an Auxiliary Lane of sufficient length which would permit acceleration of entering vehicles as well as enable each of them to pick an accept safe gap to merge with the main-line traffic.

XI Weaving Sections

i) Typical Lane change and Weaving situations would arise (i) on the upstream of an Exit Ramp (or entry into a lay-bye) when vehicles in the fast lanes intending to take the nearest exit would change lanes and weave to approach the Exit Ramp, (ii) on the downstream of an Entry Ramp when entering vehicles having far off destination may change from the slowest lane at the entry to the fastest lane closer to the median, and (iii) when an Entry Ramp is closely followed by an Exit Ramp, a combination of situations (ii) and (i)

ii) Weaving sections of adequate length and capacity shall be provided at the situations listed above.

XII Access paths

i) Access Paths shall be low grade roads running parallel to the ROW boundaries and located outside of the Expressway fencing. Width of the Paths shall be 3 m and pavement shall be in stabilized soil, stabilized gravel or local aggregates. Access paths shall be formed within the 5m wide strip between the inside edge of the ROW boundary and the outside edge of the Expressway fencing. Access path shall be provided where property severance is encountered due to Expressway ROW acquisition and shall be connected to Access Underpass to be provided at 2 km interval for facilitating access to the severed properties. The remaining 2m wide strip out of the 5m wide strip shall be utilized as utility corridor to be developed as per the requirement of Utility Agencies.

XIII Access underpass

i) Access Underpass shall be two RCC boxes 4m widex3m high, one under and across each carriageway. The Floor level of the boxes shall match the FRL of the Access path and the overburden on the boxes shall be that of the Subgrade and the overlying Pavement and

shoulders. There shall be a vertical RCC collar at the top edge of the box on each face of the box to retain the overburden. The length between the inner faces of the two boxes shall be equal to the median width and shall remain open to the sky but covered with iron grill at the top along with polycarbonate sheet.

ii) In the open to sky portion a 5m wide concrete floor slab concentric with the centerline of the floor of the boxes shall be provided to act as a passing place for vehicles from the opposing sides. The top of the concrete slab shall be flush with the floor of the boxes and the entire underpass and this concrete floor slab shall be in unidirectional slope of 1:1000 to drain the surface runoff, which shall be discharged in a rain water harvesting pit.

iii) The earth along the edges of the slab shall be retained by RCC Retaining Wall and the iron grill shall be supported on the top of the retaining wall such that the movement of the grill due to expansion/contraction is not restrained.

XIV Cross road overpass

i) All existing roads that intersect the Expressway alignment, regardless of their classification, shall cross the Expressway over a bridge structure. The bridge shall have as many lanes as the intersecting road has, provided that the bridge width shall not be less than 2-lane. The bridge structure and its approaches shall provide only a cross over facility and not an access to the Expressway, even a left turning access. The access to the Expressway shall be determined on other considerations as spelt out in this Manual.

ii) It is not necessary to follow the existing alignment of the cross road to locate the bridge structure. The cross road may, if necessary, be realigned and the bridge and its approaches constructed on the changed alignment. Attempt shall be made to keep the extra travel distance due to realignment as short as practicable from safety and operational considerations.

iii) The overpass structure shall span the entire Expressway from the outer edge of the earthen shoulder of one carriageway to that of the other carriageway. In other words, there shall be no pier in the median. Minimum clearance of the soffit of the bridge from the point of maximum elevation of the carriageway below the bridge shall be 5.5 m.

iv) Except where the overpass structure is a part of the Interchange complex and the entire development is required to be carried out by the Authority within this ROW, the Authority shall complete the Approaches to the Overpasses along with Crash barriers and fencing, if considered necessary, upto the limit of the Expressway ROW. The State/Local Authority shall complete the connectivity.

XV Lay-byes

Lay-byes shall be provided for various purposes, such as View Points, Waiting Area for vehicles in distress, temporarily stationing the maintenance and operations vehicles and crew, Bus Stops, if any, Service Areas. The length of the Lay-byes shall be enough to accommodate at least three vehicles of the type likely to use the Lay-bye and its width shall be at least 7m. The taper shall be 1:15. Each lay-bye shall be preceded and followed by an Auxiliary Lane.

XVI Service Areas

i) Service Area shall be located at an interval of 50 km approximately and shall have, at the minimum, facilities for parking, eating, beverages shops or dispensers, toilet, drinking water, shopping kiosks, desirably, fuel station, repair shops, open spaces and green areas, walking malls, seating benches, recreation facilities for children.

ii) Parking demand (numbers arriving) and the occupancy of a parking slot (average duration a slot remains occupied) would be the main determinant for the size of the Service Area. Assuming parking to be full at any point of time (i.e., at the peak hour), if the rate of arrival is less than the rate of departure, a Parking slot would be available and there will be a shortage if reverse is the case. The rate of arrival, departure and occupancy shall be determined by appropriate survey. Area requirement for other purposes would be determined by standard norms of space per person.

iii) Frontage of Service Area shall be wide enough to accommodate two vehicles plus 1 m per vehicle for pick up and drop. There shall be proper circulation of vehicles from frontage to the Parking Area.

iv) There shall be parking space for at least two disabled drivers right at the frontage.

v) Entry and exit to a Service Area shall be only through auxiliary lanes followed/preceded respectively by lay-byes. During peak hour the auxiliary lane at entry can serve as a storage lane for vehicles in queue for parking. In order to make sure that the queue does not spill on to the main line, parking availability shall be displayed right at the beginning of the auxiliary lane.

XVII Toll Plazas

i) Tolling system shall be a closed tolling system unless specified otherwise by the Authority, with toll deducted at the exit. Therefore, in addition to toll plaza location, FASTag detector shall be erected at every entry (to record its entry) and exit (to debit the toll from Toll Plaza from the FASTag balance).

ii) Toll Plaza shall be located off the main-line Expressway to ensure that the vehicles not exiting at the plaza do not suffer any delay.

iii) Toll Plaza should preferably be integrated with and interchange to ensure land efficiency.

iv) Toll collection algorithm would completely change with switch over from open to closed toll system. In order to avoid any delay in the transition period, the Consultant shall be in touch with the toll managing Bankers to alert them for changing their tolling algorithm and assist them by providing the required information.

XVIII User Services and Intelligent Transport System (ITS)

i) The Authority's Consultant shall give a recommendation on an appropriate National ITS Architecture within which the user services envisaged in this Project can be provided and seamless integration of the existing stand-alone ITS applications as well as of any future user services are enabled. The context of a National ITS Architecture is described below.

ii) The Project Expressway will, to start with, provide its users three sets of user services, viz., (i) Expressway Information, (ii) Traffic Management, and (iii) Incident and Emergency management. The Expressway users would need to be provided real time information on these three operational aspects of the Expressway.

iii) Three sets of user services, viz. (i) Vehicle Registration (Vaahan), (ii) Driver Licensing (Saarathi) and (iii) Electronic Toll Collection (ETC) have already been made available to the users, operators and law enforcing authorities. If these are integrated with the services proposed to be provided on the Expressway, the Expressway user can access on-line his/her vehicle registration, driving license, toll balance and comply with any legal requirements associated with them (e.g. extension of validity of the documents, recharge of toll, application for any required permits, etc.).

iv) It is not the Expressway user alone, which is of concern to the Authority, but any user anywhere in the country would require numerous services to be provided on-line (e.g., travel conditions on any particular road, quality of journey and travel time, availability of a multimodal transfer facility like Air/Rail, Air/Rail travel schedules and delays, the prevailing traffic condition on the local route at the destination). The user service provided at this Expressway would be one such set of information that may be of interest to those users who choose to use the Expressway, but not to all users in the country who may need to be connected to all transportation service providers to make informed choices about their travel.

v) Each transportation service provider collects data from the field (say by in-field sensors), which may be communicated to some Centres (say, by internet or wired communication system), the Centres may process the information (say, by using appropriate algorithms), and transmit the processed information to the users of its service (say, on a field display device) in Centre-to-Field communication. The Centre may pass on the processed information to other Centres in a Centre-to-Centre Communication. All the Centres may get connected to the Service Provider's Portal, which can be accessed by any user. The user can navigate through various Service Providers' Portals and access the information of their interest.

vi) The connectivity of the users to the service providers at national level would require a National ITS Architecture to be devised, which should standardize the systems (e.g., communication system), data communication protocol (e.g., Open System Interconnection, OSI) and various system components and devices (e.g. field devices and their electronics).

vii) There are two models of a national ITS structure, USA's "National ITS Architecture" and Europe's "Frame Architecture". The US system lays down the architecture by defining the user services and the system layout. The component manufacturers have to manufacture products meeting the standards developed by collaborative efforts of manufacturing industry and research institutions, such that the products are interchangeable (i.e., the product of one make can be replaced by another make) and interoperable (i.e., the system would work even with such replacement). The Europe's Frame Architecture on the other hand targets specific user services, puts in place the layout of the system and the components using the ISO and EN standards and

Protocols. Various user services grow organically bottom up and are connected to one another to give a seamless nation-wide application, again following the ISO and EN standards.

viii) In the light of the above background the Consultant shall propose an ITS architecture, which can be upscaled as a National ITS Architecture. The Consultant shall make generic recommendation about the interconnection between the field devices (each being a node on the communication network) and the Traffic Control Centre through a communication network, the communication system technology and data transmission protocol, the communication system layout and the standards to which each component of the system (hardware as well as built-in electronics) should be manufactured or built to ensure vendor neutrality, interchangeability and interoperability. Arising out of these generic recommendations, the Consultant shall make project specific recommendations.

XIX Traffic Control Centre

i) Traffic Control Centre shall be the repository of all data gathered by the sensors from the Field, which will reside on a server (physical or cloud-based from where these can be retrieved in near real time for processing by appropriate processing algorithms. The processed information shall be stored as a back-up in a database and simultaneously acted upon.

ii) The actions, inter alia, shall be (i) to make traffic management decisions and intervene by activating/deactivating appropriate signals such as lane closed/ open, ramps closed/open, ramp metering, (ii) to send advisories to users on the Field Display Units such as Variable Message Signs, about congestion, closure of lanes/entry/exit, alternative entry/exit/route, speed, time to certain destinations, occurrence of incidents or emergencies, inclement weather, etc. (iii) to alert and organize the maintenance and operation teams to intervene in case of incidents, iv) to alert and organize the emergency management teams to intervene, (v) to get feedback from the users and the intervening teams, (vi) to revisit the advisories and change them based on the feedback.

iii) All field devices (sensors, CCTV cameras, VMS, toll plaza, service areas) will be nodes on the communication system network linking them to the Traffic Control Centre between which two-way communication link shall be established (e.g., while the camera feed reaches the Control Centre, the latter can remotely instruct change in the camera angle or zoom on a particular spot). The Communication network shall be set up accordingly.

iv) Software to reside on Traffic Control Centre's server shall include but not limited to (i) decoding the sensor signals into spatial and temporal vehicular detection (presence and passage, their classification, vehicle counters); (ii) algorithm to convert the vehicular data into traffic flow parameters (speed, flow, density, headway, occupancy); (iii) Artificial Intelligence (AI) based Video Image Processing (VIP) algorithm that can detect the vehicles, their shapes and outlines against various background lighting conditions during the 24 hour day and trace their trajectory; (iv) algorithm to make traffic management decisions based on the vehicular and flow data; and (v) algorithm to make the field display units respond to the instructions when transmitted to them.

v) Traffic Control Centre's digital infrastructure shall be Internet connectivity of appropriate speed, video wall of appropriate resolution, data and software servers of adequate storage capacity, computer consoles in adequate numbers, dedicated telephone lines, transceivers to operate on allotted frequencies (car radio transmission), Public Address System.

XX Tunnels (if required) including lighting and ventilation

i) Choice of tunnel technology (i.e., Cut and Cover or Bored tunnel) shall be decided based on the ground strata, height of overburden, construction time, tunnelling equipment requirement and comparative cost assessment of various alternatives.

ii) Tunnel geometry shall be decided on the basis of its functionality (e.g., the cross section to be carried through), accommodation of services infrastructure (e.g., fire hydrant, inspection walkway), access for maintenance (e.g, head room for inspection and maintenance).

iii) All tunnels shall be provided with lighting (to illuminate the tunnel 24x7), ventilation (to remove the toxic fumes of vehicular emission and keep the tunnel air clean as also to remove the smoke during fire incidents), escape routes (to evacuate the users during fire and other emergencies), fire protection systems both passive (to protect damage to the tunnel structure from heat transfer during fire incidents) and active (to fight the fire occurring inside the tunnel), and a centralized control system for the tunnel operation (to activate/deactivate the tunnel equipment and installation).

iv) All overhead equipment and installation (e.g., fire-proof cladding, exhaust fans, lighting installations, etc.) should be 'fall safe' under normal tunnel operation

v) Lighting system shall be so designed that the change in lighting intensity (e.g. 200 LUX or higher outside the tunnel during day time and 40/60 LUX inside the tunnel) from the entry and to the exit is gradual and there is no blinding effect after entry and before exit.

Where longitudinal ventilation arrangement is made, reversible axial exhaust fans shall be installed for ventilation. The fans should be functional for at least 2 hours under design fire condition or withstand the temperature of at least 250 degrees Celsius for two hours. Where vertical ventilation shafts are to be provided, centrifugal fans shall be used to remove the exhaust/ smoke.

XXI Road sensors

i) Road sensors shall be provided (below the surface or on the sides or over the road) to record the presence and passage of a vehicle. The built-in algorithm of the sensor electronics should be able to convert the sensed data into the numbers (vehicle count), vehicle dimensions (and from pre-fed dimensions of various categories of vehicles, their classification), vehicle speeds (by sensing the same vehicle by two sensors separated by a certain distance and clocking the time interval between two passages), vehicle axle weights (using load cells).

ii) The sensed data shall be communicated to the Traffic Control Centres over the Communication network and reside in the Control Centre's servers from where it can be used for computing various traffic flow parameters (speed, flow, density, gaps and headways, occupancy) using a suitable Traffic Management System algorithm, which shall be separately developed.

iii) There shall be freedom to choose any sensor technology (e.g. inductive loop, microwave, infrared, video imaging) so long as (a) the sensor accuracy is more than 95 per cent, (b) sensors are interchangeable (i.e. vendor neutral) and (c) these are interoperable (i.e., irrespective of sensor technology, the sensor outputs can be used directly as inputs in the traffic management system algorithm).

iv) Interchangeability and interoperability of the sensors would be made possible only if the sensor vendors can assure that their products have been manufactured meeting the same international standards (say ISO), and are capable of (a) interfacing with the communication network, and (b) two-way communication of the data between the sensor and Control Centre following the OSI protocol.

v) There shall be redundancy (say 30 per cent) built into the sensor provisions so that demise of some sensors does not affect the overall functioning of the system.

XXII CCTV Cameras

i) CCTV cameras shall have full coverage of the Expressway and the facilities. The Camera features (resolution, zoom, PAN, camera electronics), locations (at which to be up), and mountings shall be such that enables the entire length of the Expressway and all the vantage points of the facilities (ramps, ramp terminals, interchanges, toll plazas, fencing, over/underpasses) to be in the field of view of some camera or the other.

ii) Camera controls (angle, PAN, tilt, zoom) shall remain with the Traffic Control Centre, which can remotely change the camera settings of any camera to view and zoom on the images of any location or object.

iii) Images shall not be live streamed to the Control Centre but first recorded and then streamed in near real time.

iv) Three types of cameras with different built-in electronics shall be used on the Project Expressway, (a) one which can simply send digital images of the scene, (b) one which can work on infrared sensors (night vision) and send images where lighting condition is poor, and (c) one which has video image processing (VIP) capability, can delineate the outline of vehicles against different back ground light and can track vehicle movements. The first type shall be deployed where lighting condition is good throughout the 24-hour day (either by natural light or by illumination) to view the general traffic conditions (e.g., congestion build up, occurrence of an incident, etc.). The second type shall be deployed at sensitive locations which are poorly lighted during night. The third type shall be used either alone or in combination with the second type where the images are used for determining the traffic flow parameters (speed, flow, density, headway, etc.).

XXIII Lighting

All ramps, Ramp Terminals, Interchanges, Service Areas, Toll Plazas shall be illuminated by high mast lighting and/or post-mounted lights. The minimum intensity of light within the designated illuminated area shall be 40 LUX, which shall gradually fade to the normal night time illumination level in a length not less than 500 m on either side of the area. For better illumination, poles shall be provided alternatively on LHS and RHS, wherever feasible.

XXIV Signals

i) There shall be no Traffic Signals on Expressway, which will stop the Expressway traffic to cede right of way to any other traffic. Nevertheless, signals shall be installed on the Expressway to guide the users on lane/ ramp closures (indicated by red light) and reassure them that they are entering into or travelling on permitted directions or lanes. Signals shall also be installed to bar unauthorized entries, exits and travel (indicated by red light). Signals shall also be installed for ramp metering. Signal installation may be on overhead gantries or post mounted. These shall be supplemented by display of appropriate messages on Variable Message Signs or in Fixed signs.

ii) Following are some typical locations where signals shall be installed.

a) On overhead gantries across the Expressway Carriageway over the middle of each traffic lane and paved shoulder. The default mode of these signs shall be green for each traffic and red for shoulder. The sign should change to red on any lane if that lane is closed for some reason. On the shoulder the sign should change to green only when shoulder use is specifically permitted by the Traffic Control Centre (e.g., to clear congestion or to be used as a storage lane during congestion). 'Lane closed' or 'Shoulder use permitted' shall be simultaneously displayed on the Variable Message Sign mounted on the same Gantry.

b) On entry ramp terminal on the minor road, the default mode for the lane permitting entry shall be green unless the entry is barred for any reason (say congestion or incident) when the signal should show red. There should be corresponding signal display at the other end of entry ramp as well (i.e., at the Expressway end). Entry closed message on VMS should be displayed before entry if entry is barred.

c) On exit ramp terminal on the Expressway, the default mode shall be green, which should turn red if the road down stream of exit has some problems and exiting traffic might get stuck. There should be corresponding signal display at the minor road end of the ramp as well. VMS display should be 'Exit Closed, Take next Exit'

d) Permanent red and No entry signal at the minor road at the exit location to rule out wrong side entry

e) Permanent red and No exit signal at the minor road end of the entry ramp to rule out wrong side exit.

f) Permanent green at entry and exit of lay-byes unless entry or exit is barred for some reason.

g) Ramp metering signal ahead of the entry to the expressway with alternate red and green to avoid platooned entry.

XXV Traffic Signs including Variable Message Signs and Pavement marking:

i) There are IRC standards on the subjects (IRC 67, IRC 35 and IRC:SP:85), which specify different types of signs and markings (signs, words, legends) and their dimensions (e.g. board size, letter size, line width, arrow size), their colour schemes (background and message colours), the quality of signing and marking materials (e.g. retro-reflectivity of sheets, boards, paints), sign mountings and placement, multi-lingual display requirement, placement of delineators etc. These shall be strictly followed.

ii) However, there are certain gaps or lack of clarity in these standards, particularly with regard to

a) Guidance on placement of signs from spatial (in three dimensions, along, across and above the highway) and temporal (time to respond to the messages) considerations: Spatial consideration shall involve visibility distance, legibility distance, the angle of sign face with respect to traffic direction, and solid angle on human eyes. Temporal consideration would be about exposure time of the signs to human eyes to register the message, effect of varying background and background lighting during the day,

b) Continuity and consistency of messages: A message requiring action by the user should start with informing him of the action and continue till the action is about to be accomplished. For example, information about an approaching exit should be repeated till the exit is actually reached and take exit sign is displayed, or a direction about reducing speed should end with the reduced speed limit sign after the deceleration zone, or a direction like lane change prohibited should end with a lane change permitted sign.

c) Complementing signs by marking: This should always be ensured to reinforce the import of the message on signs. For example, a direction to prepare for and change lane should be complemented by arrow marking in the direction of change followed by dashed line permitting the entry into a lane,

d) New signs: Certain new signs and/or messages like Service Area, Merge Area, Diverge Area, Ramp metering, Entry/Exit Ramp Closed, Take next exit, Exit through Exit Lane only, Exit Lane, etc. have to be devised.

e) Variable Message Signs: A library of messages shall be built with blank fields for input data. The Control Centre would choose one that is relevant for display, input the data, send command to the VMS controller and the built-in electronics of the Controller will display the message. The message will be near real time information on road, traffic and weather conditions. The traffic management algorithm will calculate the traffic flow conditions based on which information as relevant on

congestion, delay, expected travel time, over speeding, unsafe headway, unsafe gap, lane closure status, ramp closure status, etc., shall be displayed.

VMS hardware and built-in electronics should be vendor neutral and interoperable.

In order to bridge the gap between whatever is available in the IRC standards and what is required to be provided other international standards shall be referred to. One such standard is the MUTCD. The principles and practices stated therein shall be applied for devising the signing and marking system for the Project Expressway.

XXVI Incident and emergency management equipment and infrastructure:

i) Incident and Emergency Management may need involvement of other agencies, not necessarily under the Authority or the Concessionaire/Contractor (e.g., a Road clearing Contractor, a Trauma Centre, the Fire Brigade, the Police). The Project Expressway shall have adequate infrastructure to accommodate them and their equipment on the Project. Expressway for their timely intervention and efficient performance.

ii) Such infrastructure planning shall keep in mind the logistics of the movement between their respective stations and the incident sites without violating any of the access control measures and traffic operation requirements on the Expressway.

XXVII Operation system layout, Standard Operating Procedure and Protocol:

i) The inter-agency coordination for incident and emergency management is important and shall be formalized in the form of Memorandum of Understanding and Standard Operating Procedures. These shall involve delineating the responsibility of action by each agency, the personnel responsible for action, the manner in which the information on incidents and emergencies is to be received and passed on to the concerned agency/personnel, the response time for initiating and accomplishing the action, the feedback of the response team from the field as to clearance of the incident and restoration of normalcy, displaying all clear information on the VMS

ii) The draft of the MOU, Protocol of action and Standard Operating Procedure for incident and emergency management shall be prepared.

C. Clear Zone

A clear zone is the unobstructed traversable area provided beyond the edge of the through carriageway for the recovery of errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear run-out area. The desired minimum width is dependent upon traffic volumes and speeds and on the roadside geometry. The concept is illustrated in **Fig. 2.2** (adapted from AASHTO Roadside Design Guide).

D. The requirements stated above (ref Paras A, B and C of these guidelines) are not the complete terms of reference of the Consultants, the Authority shall include them in toto in the TOR of the Consultant.

SECTION 2

GEOMETRIC DESIGN AND GENERAL FEATURES

2.1 General

i) This Section lays down the standards for geometric design and general features for expressways. The application of geometric standards should aim at achieving safety, mobility and efficiency in traffic operation.

ii) The decision for development of a corridor / portion of a corridor as a Brownfield or Greenfield alignment shall be taken on the basis of total life cycle cost (including direct costs like Civil Construction Cost, Maintenance cost and economic costs like Vehicle Operating Cost), traffic bearing capacity for a period of 30 years and the potential to diversify traffic and reduce distance between Origin- Destination pairs in the network.

iii) The geometric design of the 6-lane Project Expressway shall conform to the standards set out in this Section as a minimum. The Concessionaire shall ensure that liberal geometric standards are followed to the extent feasible within the given Right of Way.

iv) As far as possible, uniformity of design standards shall be maintained through out the length of the Project Expressway. In case of any change, it shall be effected in a gradual manner.

v) The geometric design should address environmental concerns and provide positive guidance to the driver to travel safely.

2.2 Design Speed

2.2.1 The design speeds given in **Table 2.1**.

Table 2.1 Design Speed

Project Component	Design Speed (km/hr)
Main-line Expressway	120
Ramps including loop ramps	70

2.2.2 The design speed shall be uniform along the Expressway. For those sections of Expressway where variations in terrain may make changes in speed unavoidable, the design speed shall be changed in the gradual manner, by introducing sections of increasing/decreasing design speed as the case may be.

2.3 Right-of-Way

2.3.1 The Right-of-Way (the ROW) for the Project Expressway shall be as given in **Schedule-A** of the Concession Agreement. The Authority would acquire the additional land required, if any, and the same shall be indicated in **Schedule-A** or **B** of the Concession Agreement. The recommended minimum Right of Way in Plain/Rolling terrain for expressways is given in **Table 2.2**.

Table 2.2 Right of Way in Plain/Rolling Terrain

Section	Right of Way (RoW) Width
Rural Section	100 m
Rural Sections passing through semi- urban areas	120 m

Additional land at bridge approaches, grade separated structures, interchange locations, toll plazas and for project facilities shall be acquired as per design. The ROW width includes 5.0 m wide strip on either side reserved for Access Path and placement of utilities outside fencing. In the stretches where elevated expressway on viaduct is proposed, the width of ROW may be reduced as per site conditions and availability of land. This aspect should be finalized at the DPR stage and before bidding for the project.

2.3.2 No service roads shall be provided within the ROW of the Expressway.

2.3.3 Fencing

The entire acquired Right of Way (ROW) of the Expressway minus a 5 m wide strip on either side shall be fenced. Fencing shall extend to any location from where there is a chance of any unauthorized entry within the functional ROW and shall include the outer limits of any ramps, interchanges, service areas, toll plazas, etc., which are not completely located within the fenced area.

Fencing shall be of 3 m height in iron grill with the top vertical member having pointed tips. The horizontal spacing of 3 m shall be provided. The grill pattern in other portions shall be such it does not permit entry of humans and animals from the side. The fencing shall be painted white or yellow colour with Authority logo. ROW boundary pillars shall be fixed at a distance of 100 m. at the both edge of ROW.

2.4 Lane Width of Carriageway

The standard lane width of the Main-line Project Expressway, ramps, lay byes and auxiliary lane shall be 3.75 m. Expressways shall have three lanes for each direction of travel.

2.5 Median

2.5.1 The width of median is the distance between inside edges of carriageways. The median will be depressed having 15 m width between the outside edge of inside shoulder of the two carriageway that slopes down towards the median center line in 6 H:1 V resulting in a 'V' shaped lined ditch to act as *median drain*. For median, following shall be followed invariably:

i) Only depressed median shall be provided. No Raised median / kerbs shall be proposed.

ii) In case of narrow medians(2m or less wide), as generally provided in urban areas, New Jersey type concrete crash barriers shall be provided along with anti-glare screen on both side of the median.

iii) In already developed multi-lane expressway /highways with raised median especially in open country / rural areas, these shall be replaced by depressed median. Alternatively, crash barrier may be provided along raised median in such a way that the face of the crash barriers is flushed with the face of the raised median.

iv) To enable fully access control facility, Thrie beam metal crash barrier shall be provisioned at both edge of roadway and both sides of median to ensure safety. These shall be located in a manner that the vertical tangent to the thrie beam crests passes through the edge of the paved shoulder.

2.5.2 The depressed median shall have suitably designed drainage system with lined drain so that water does not stagnate in the median.

2.5.3 As far as possible, the median shall be of uniform width in a particular section of the Project Expressway. However, where changes are unavoidable, a transition of 1 in 50 shall be provided.

2.5.4 The Project Expressway shall be a free-flowing facility without any conflicting movements and hence without signal controls. Any vehicle that enters the Expressway shall continue to travel in the same direction (i.e., straight direction) and can not turn left or right except at the ramps, where it will be permitted only a left turn. The 'main line' expressway traffic can take a right turn either through a loop ramp, where it is provided (as an interchange), or through an 'off-line' right turning facility after exiting the expressway through a left-out exit ramp. This would mean that there shall be no median opening between any successive ramps causing conflict with the on-coming traffic needing to be controlled by signals. There shall, however, be a collapsible or movable median barrier at every 5 km interval for traffic management for maintenance works and removal of vehicles involved in accidents.

Such barriers shall be located before and after tunnels, interchanges, and rest areas. These barriers shall remain in 'locked' mode, except in emergencies, when it will be

'opened' only for emergency intervention. Length of Median opening shall be not less than 20 m (for emergency and for repair/maintenance works).

2.5.5 Median barriers shall be provided as specified in Section 10 of this Manual. Suitable antiglare measures such as metal/plastic screens shall be provided to reduce headlight glare from opposite traffic. The total height of screen including the height of the barrier shall be 1.5 m. These shall be located in a manner that the vertical tangent to the thrie beam crests passes through the edge of the paved shoulder.

2.6 Shoulders

2.6.1 The shoulder on the outer side (left side of carriageway) shall be 3.0 m wide paved plus 2.0 m wide earthen and 0.75 m wide paved on the inner edge (median side). The shoulder composition shall be as below:

i) The composition and specification of the paved shoulder shall be as that of the main carriageway.

ii) The earthen shoulder shall be provided with 200 mm thick layer of non-erodible/ granular material (preferably fine graded GSB material) for protection against erosion.

2.7 Roadway Width

2.7.1 The width of roadway shall depend upon the width of carriageway, shoulders and the median.

2.8 Camber / Cross Fall

2.8.1 The cross fall on straight sections of expressway carriageway shall be 2.5% for Main-line carriageway, paved shoulder and edge strip (paved shoulder on median side) for bitumen surface and 2% for cement concrete surface. Each carriageway shall have unidirectional cross fall.

2.8.2 The cross fall for earthen/granular shoulders on straight portions shall be at least 1 percent steeper than the values given in **Para 2.8.1 above**. On super elevated sections, the earthen portion of the shoulder on the outer side of the curve would be provided with reverse cross fall so that the earth does not drain on the carriageway and the storm water drains out with minimum travel path.

2.9 Super Elevation

Super elevation (for main-line, ramps & loops) shall be limited to 7 percent, if radius of curve is less than the desirable minimum radius. It shall be limited to 5 percent if radius is more than or equal to the desirable minimum super elevation shall not be less than the minimum specified cross fall.

2.10 Embankment Slope

The embankment slopes shall be in 4 H: 1V or flatter and cut slopes in 2:1.

2.11 Design of Horizontal and Vertical Alignment

The general principles and design criteria laid down in MoRTH Guidelines for Expressways shall be followed except as otherwise indicated in this Manual.

2.11.1 *Horizontal Alignment*

Alignment shall be fluent and blend with the topography. The horizontal curves shall be designed to have largest practical radius and shall consist of circular portion flanked by spiral transitions at both ends.

2.11.2 *Radii of Horizontal Curves*

The desirable minimum and absolute minimum radii of horizontal curves are given in **Table 2.3**.

Table 2.3 Minimum Radii of Horizontal Curves

Description	Main-line	*Ramps
Desirable Minimum Radius (m)	1000 m	300 m
Absolute Minimum Radius (m)	650 m	

***Note**: All the provisions of ramps will apply to loop ramps as well except the loop curvature, which can be reduced to the minmum of 170m

The radius of horizontal curves for various terrain conditions shall not be less than the desirable minimum values given in **Table 2.3** except for sections as indicated in **Schedule B** of the Concession Agreement. For such sections, the radius of curve shall not be less than the absolute minimum.

2.11.3 *Transition Curves*

Properly designed transition curves shall be provided at both ends of the circular curve. The recommended minimum length of transition curves is given in **Table 2.4**.

Table 2.4 Minimum Length of Transition Curves

Description	Minimum Length of transition curve (m)	Remarks
Main-line	70 m	This should be designed as cubic spiral and should be checked for safe rate of change of super elevation.
Ramps	40 m	

2.11.4 *Sight Distance*

2.11.4.1 A minimum of 500 m of sight distance shall be available throughout.

2.11.5 *Vertical Alignment*

2.11.5.1 Vertical Alignment Design

The vertical design, especially at grade change location, such as VUP, ROB, Bridge locations will be done using **Minimum Sight Distance** (500 m).

The vertical alignment should provide for a smooth longitudinal profile. Grade changes shall not be too frequent as to cause kinks and visual discontinuities in the profile. Desirably there should be no change in grade within a distance of 150 m. The directions given in **IRC:73** and **IRC:SP:23** should be complied. Decks of small cross drainage structure (i.e. culverts or minor bridges) shall follow the same profile as the flanking road section, without any break in the grade line. The aspect of efficient drainage shall be kept into consideration while designing vertical profile and cross-sections of the Project Expressway as stipulated in **IRC:SP:42** and **IRC: SP:50.** The vertical alignment shall be coordinated with the horizontal alignment as indicated in **Para 2.9.6.4**.

2.11.5.2 Gradients

The gradient shall be 2% In cut-sections, minimum gradient for drainage considerations shall be 0.5 percent (1 in 200) for all types of drains (lined or unlined)

2.11.5.3 Vertical Curves

Long sweeping vertical curves shall be provided at all grade changes. Summit curves and Valley curves shall be designed as square parabolas. The length of the vertical curve is controlled by sight distance requirements, but desirably curves with longer length shall be provided from aesthetic considerations. The minimum grade change requiring vertical curve and the minimum length of vertical curve shall be as given in **Table 2.6**.

Table 2.6 Minimum Length of Vertical Curve

Design speed (km/h)	Minimum Grade change requiring Vertical Curve	Minimum Length of Vertical Curve (m)
120	0.5 %	100

2.11.5.4 Coordination of horizontal and Vertical alignment

The overall appearance of an expressway can be enhanced considerably by judicious combination of the horizontal and vertical alignments. Plan and profile of the road shall not be designed independently but in unison, so as to produce an appropriate three-dimensional effect. Proper co-ordination in this respect will ensure safety, avoid visual discontinuities and contribute to overall aesthetics.

Vertical curvature superimposed upon horizontal curvature gives a pleasing effect. As such the vertical and horizontal curves shall coincide as far as possible and their length shall be more or less equal. If this is difficult for any reason, the horizontal curve shall be somewhat longer than the vertical curve. Short vertical curve superimposed on long horizontal curve and vice versa gives distorted appearance and shall be avoided. Sharp horizontal curves shall be avoided at or near the apex of pronounced summit/ sag vertical curves from safety considerations.

The designer shall check profile design in long continuous plots to help avoid a roller-coaster profile.

2.12 Facility Planning

The following facilities shall be created on Expressway.

2.12.1 *Auxiliary lanes, lay-byes and ramps*

a) Auxiliary lanes

Auxiliary lanes shall be provided to ensure that lane balance is maintained, there is no lane drop and the traffic merges with the expressway or Frontal Road traffic nearly at the same speed as the operating speed of the Expressway or the Frontal Road as the case may be. These shall be provided ahead of or beyond the Ramp Terminals in the following manner:

Left-in left-out ramps connecting Frontal Roads

i) Exit from expressway: Up-stream of the exit ramp before exit on the main-line expressway

ii) Entry into expressway: Down-stream of the entry ramp after on the main-line expressway

iii) Entry from Exit Ramp on to the Frontal Road: Down-stream of the entry on the Frontal Road

iv) Exit from the Frontal Road on to the Entry Ramp: Up stream of the exit on the Frontal Road

Interchange Ramps including Loop Ramps

Auxiliary lanes shall be provided at both Ramp Terminals regardless of the location of the Terminals on the Expressway or any other road.

The lane width of auxiliary lanes shall be 3.75 m and 1.0 m wide paved shoulder.

The length of the auxiliary lanes shall be decided on the basis of the operating speed differential on the expressway and ramps on the ramp side terminal and that between

the ramps and the Frontal Road on Frontal Road side Terminal. These lanes may also temporarily hold some vehicles in queue when the demand for exit or entry exceeds the capacity. The queue length during peak flow shall also be a consideration in deciding the auxiliary lane length.

b) Lay-byes

Lay-byes shall be provided for (i) stationing operation teams (e.g. patrol vehicles, ambulances, cranes and maintenance vehicles), (ii) entry and exit to the Service Areas, (iii) parking of disabled vehicles, (iv) view points on the expressway, if any. Each lay-bye shall be preceded and followed by auxiliary lanes.

Lay-byes shall have minimum two-lane width (each 3.5 m wide) to enable a vehicle to pass a stationary vehicle. The inner side of the lay-bye shall have 0.6m wide paved shoulder and the outer side shall have a kerbed footpath at least 2.0 m wide. The straight length shall be able to accommodate at least three vehicles of the size likely to use the lay-bye. Taper shall be 1in 30 and the tapered area shall also be kerbed without foot path.

c) Ramps

Ramps are the road links that collect the traffic from a road link of an independent road network, which needs access to the expressway (entry ramp) and distributes the traffic exiting the expressway on to the network (exit ramp). Where the road link is an intersecting important road (National Highways, State Highways, Urban arterials, etc.) an interchange shall be provided to satisfy the demand for turning in all directions from all intersecting legs. Such ramps shall be called interchange ramps. Where the road link is not of that importance but still has considerable locally generated access demand and can provide quick dispersal of the expressway traffic to local destinations, ramps shall be provided to meet the turning demand for only one direction, i.e. 'left'. Such ramps have been termed in this Manual as 'left-in-left-out ramps' (this is only to distinguish such ramps from 'interchange ramps', conceding though that even the interchange ramps permit only left turn movement on the interchange). It is not necessary for the roads having one terminal of the left-in-left-out ramp to intersect the expressway and may even run parallel to the expressway. Such roads shall be called Frontage Road in this Manual.

Lane configuration of ramps shall depend upon the capacity of the ramps as well as ramp terminals (the merge and diverge areas for entry and exit ramps respectively) and the target LOS. It must, however, be borne in mind that providing ramps of more than one lane would upset the lane balance on the downstream of the entry and cause a lane drop on the upstream of exit. In such cases, the entries and exits have to be either staggered or additional lanes have to be provided on the expressway.

Lane width on all ramps shall be 3.75 m and either side paved shoulder shall be 1 m.

Spacing of left-in-left out ramps shall depend upon demand but two consecutive entry-exit ramps shall not be spaced closer than 2 km.

The layout features shall be as detailed below in **Table 2.7**:

Table 2.7

Sr. No	Features	Value	Remarks
A	Lay-byes and their entry/exit		
i)	Taper length (on main line)	30:1, minimum 100 m	
ii)	Auxiliary lane length	200 m for deceleration and 550 m for acceleration	To reduce the speed from 120 to 20 kph and increase speed from 20 kph to 120 kph
iii)	Width of ramps, laybyes, Auxiliary lanes	7 m + 1 m paved shoulder on both side	
iv)	Laybye length	30 m (min.)	To accommodate at least 4 O&M vehicles To be increased as per demand on View Point laybyes
v)	Curvature at entry/exit	R=25 m S-Curve	
B	Ramps (Single lane entry/exit)		
i)	Taper length (on main line)	30:1, minimum 100 m	
ii)	Auxiliary lane length (one lane)	200 m for deceleration	140 m for deceleration from 120kph to 70 kph and 60 m for storage space for vehicles in queue for exit
		550 m for acceleration	240 m for speed differential of entry speed (70 kph) and main-line speed (120 kph) plus 210 m additional length for gap acceptance
iii)	Curvature at entry/exit	R=300m (desirable), 170m (minimum) plus transition	Corresponding to Ramp design speed of 70 kph

Sr. No	Features	Value	Remarks
iv)	Ramps (two-lane entry/ exit)	Same parameters as single lane entry/exit except the following: At exit: There shall be one Auxilary lane after the taper, which would continue for 500 m (3+1) 4-lanes, then another taper followed by another Auxiliary lane (4+1) 5 lanes total, followed by exit At entry: The mirror image of the exit ramp situation, i.e. two Auxilary lanes at entry, (3+2) 5 lanes to continue for 500m, followed by another taper and reducing the Auxiliary lane to 4, which will then merge wih three lanes without lane balance being disturbed	This is to prevent lane drop at exit and maintain lane balance at entry
v)	Loop ramps	All the provisions of ramps will apply to loop ramps as well except the loop curvature, which can be reduced to the minmum (R=170m) In addition, any merging and weaving on loop ramps shall be totally unacceptable	
vi)	Gore Areas at all exits	To be treated as per AASHTO Green Book and MUTCD, except that Crash cushion and chevron marking of the Gore shall be mandatory	
vii)	Weaving lengths	600 m on the upstream of an exit before diverge and equal length on the downstream of entry after merge	All weaving sections shall be notified by "Lane change permitted" signs

2.12.2 *Service Areas*

[The details are in **Section - 13** (Project Facilities, Service Areas, Pick-up Bus Stop, State Board Check Post)].

2.12.3 *Interchange*

The details are in **Section - 3** (Grade Separators & Interchanges).

2.13 Grade Separation Structures (Vehicular Underpasses / Overpasses)

2.13.1 There shall be no entry of vehicles into or exit from the Project Expressway except through properly designed ramps. The design of ramps shall be an integral part of the Project Expressway. These locations shall be indicated in the Schedule B of the Concession Agreement.

The structure may be either an underpass or an overpass depending upon the nature of terrain, vertical profile of road, availability of adequate right of way, etc. Unless otherwise specified in **Schedule B** of the Concession Agreement, the Project Expressway shall be carried at the existing level. The entire cost involved in raising or lowering the road would be included in the cost of the Project Expressway. Decision whether the cross road or the Project Expressway will be carried at the existing level will be taken at the time of preparing the feasibility report and would be based on considerations of drainage, land acquisition, provision of ramps for the grade separated facility, height of embankment and project economy etc. In built up areas, the Project Expressway shall be elevated on viaduct. This shall be specified in **Schedule B** of the Concession Agreement.

2.13.2 The type, location, length, number and the openings required and approach gradients for various grade separated structures shall be as specified in **Schedule B** of the Concession Agreement. The approach gradient to the grade separated structure shall not be steeper than 2.0 percent (1 in 50).

2.13.3 The approaches to structures viz VUP, , Flyover, Overpass, Bridge, ROB's etc. should be on earthen embankment wherever RoW is available or land is not costly to acquire. In case of restricted RoW/ costly land and in order to accommodate entry-exit ramp/ slip road/ service road within the available RoW, first the option of earthen embankment with RCC toe wall and slope protection may be explored. If it is not feasible, then only approaches with RCC Retaining Wall (upto 2.5 m height w.r.t. floor height of structure, as it is cheaper to RE wall for low heights) and RE wall (for height more than 2.5 m) may be used, If further RoW is not acquired for approaches due to high land cost, the same should be justified by comparing the cost of land with cost of RCC toe or retaining wall/ RE wall. Such length of RCC toe or Retaining wall/ RE wall shall be specified in **Schedule B** of the Concession Agreement.

The central portion (median) of VUP shall be open to sky and so covered as to allow air and light, but not rain water.

2.13.4 *Overpass*

All overpass structures shall be carried over the expressway with a minimum vertical clearance of 5.5 m above the outer-most edge of the paved shoulder and horizontal clearance of such a length that there will not be any component (pier/abutment) of the overpass within roadway width of ROW.

All Overpass structures shall span the entire Roadway from the outer edge of the earthen shoulder of one carriageway to that of the other carriageway without any supporting pier in the median.

The grade separated structures and their banks or piers/abutments shall not block the view of any important feature on the expressway such as signs, marking, delineation, or occurrence of any incident from a distance of 200 m and all such features shall lie within the 15^0 Cone of vision from that distance.

The gradients of approaches to the structure shall not be steeper than 2 per cent and the extent to which they lie within the fenced ROW shall be provided with fencing in addition to the metal/concrete crash barriers on the structure and its approaches. Where there is a demand for circulation of the maintenance vehicles within the fenced ROW, the approaches may provide viaduct spans.

2.13.5 *Vehicular underpasses*

Vehicular underpasses shall be provided for cross roads as indicated in **Para 2.13.1** above. If the intersection is staggered, the underpass shall be provided in such a manner that no vehicle is required to travel more than 2 km on one side of connecting road for crossing over to the other side.

2.13.6 *Facilities for pedestrians and cyclists*

Facilities shall also be planned and provided for crossing of pedestrians and cyclists through underpasses. The crossing facilities shall be provided such that pedestrians do not have to walk for more than 0.5 km to reach the crossing point. The slab culverts and minor bridges with span length equivalent or more than 5 m and not catering to perennial flow, can also be used for pedestrian and cycle crossings by providing necessary flooring. In rural stretches pedestrian/cycle underpasses shall be provided at the locations of the existing crossing points.

2.14 Clearance

The Lateral and vertical clearances for different categories of underpasses shall be as under except provided otherwise in **Schedule B** of Concession Agreement.

The minimum vertical and lateral clearance for vehicular underpasses shall be 5.5 and 20 m, respectively:

Wherever existing slab/box culverts and bridges allow a vertical clearance of more than 2.0 m, these can be used in dry season for pedestrian and cattle crossing by providing necessary flooring. However, these will not be a substitute for normal requirements of pedestrian and cattle crossings.

Desirably, the full roadway width at the approaches shall be carried through the underpass.

To minimize the use of RE walls in VUP these may be constructed using earthen slopes. To negotiate frequent rise and fall of main highway at structure approaches, gentle gradient (1 in 50) may be adopted with properly designed summit/ valley curve.

Where the expressway will be in underpass requiring continuation of safety barriers, the safety barriers must be located at distance of 0.60 m from the face of the nearest support and 0.25 m from edge of paved shoulder. Crash barriers shall be provided for protection of vehicles from colliding with the abutments and piers and the deck of the structures as per **Section 10** of this Manual.

2.14.1 Under/over passes shall also be provided across other categories of roads which cannot be terminated and are required to be continued across the Project Expressway. For such intersections where parallel cross roads are located within 2 km distance crossings may be designed as a staggered crossing by connecting parallel cross roads and taking them across the Project Expressway through a vehicular underpass/overpass. The vehicular underpasses/overpasses shall be so located that no vehicle is required to travel more than 2 km on connecting road for crossing over.

2.15 *Access path and crossing for severance*

The Access path for property and community severance shall be a 3 m wide low-grade road formed at ground level and meant only for the use of small vehicles and agricultural tractors. Top surface shall be surface dressed to avoid dust pollution. Such roads shall be formed on demand from the property owners and shall be located outside the fenced ROW. A width of 5m strip all along the length shall be earmarked for the purpose, which shall also accommodate 2 m wide utility corridor.

The circulation of the vehicles shall be through 3.5 m span concrete boxes of square cross section. The boxes shall be discontinued at the median and left open to the sky, but covered with iron grill, to allow daylight and ventilation, but not rain water. The embankment slope in the open portion shall have to be retained by concrete retaining walls.

2.16 Land efficiency

Land efficiency of the infrastructure is an important consideration in deciding the layout of the facilities. Extra land over and above the ROW land may have to be acquired for

facilities like toll plazas, interchanges and service areas. A land efficient layout shall be chosen after considering various options. For example, a trumpet layout of interchange, a staggered toll plaza and a longish service area layout may require less land. While it may be so, the functionality of the facilities shall not be compromised for effecting saving the land requirement. A comparative assessment of extra land in various combinations of the options shall be made before selecting a particular option set.

2.17 Utility Corridors

Space for 2 m wide utility corridor shall be provisioned at the extreme edges of the ROW on each side.

2.18 Typical cross sections

Typical cross sections of Project Expressway are given in **Figs. 2.1(a), 2.1(b) ,2.1(c), 2.1 (d), 2.1 (e) and 2.1 (f)**

Fig. 2.1(a) shows typical cross section for 4−lane (2x2) expressway in plain/rolling terrain, with depressed median.

Fig. 2.1(b) shows typical cross section for 6−lane (2x3) expressway in plain/rolling terrain with depressed median.

Fig. 2.1(c) shows typical cross section for 8−lane (2x4) expressway in plain/rolling terrain with depressed median.

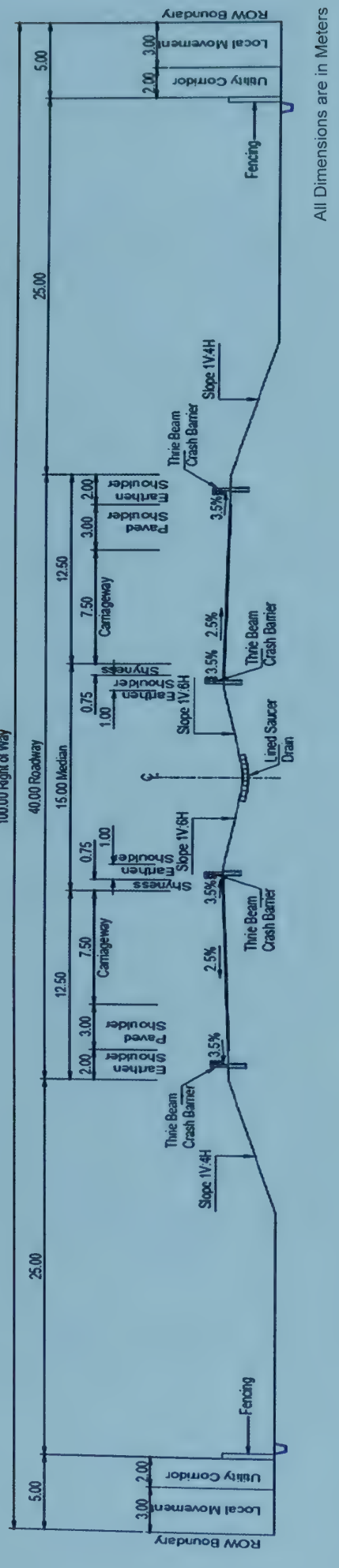
Fig. 2.1(d) shows typical cross section for 4−lane (2x2) expressway in Cut Section with depressed median.

Fig. 2.1(e) shows typical cross section for 6−lane (2x3) expressway in Cut Section with depressed median.

Fig. 2.1(f) shows typical cross section for 8−lane (2x4) expressway in Cut Section with depressed median.

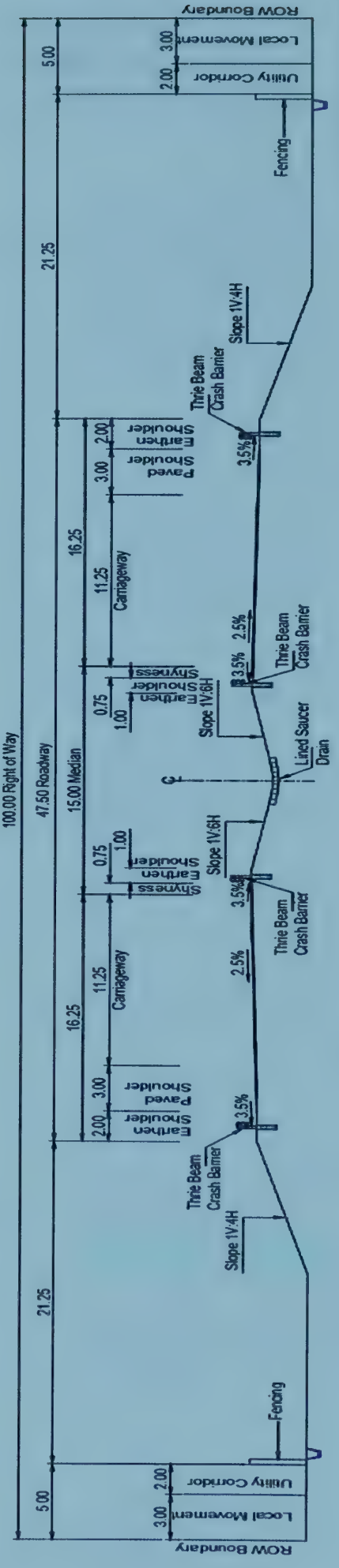
Typical cross sections for Culverts, Bridges, and Grade Separated structures are given in **Section−6** of this Manual.

Typical cross sections for Tunnels are given in **Section–7** of this Manual.



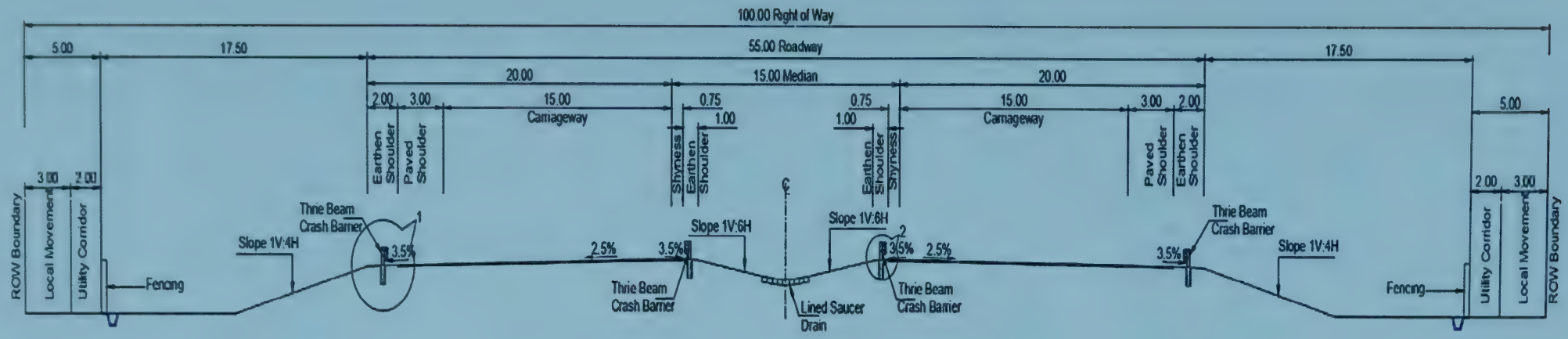
All Dimensions are in Meters

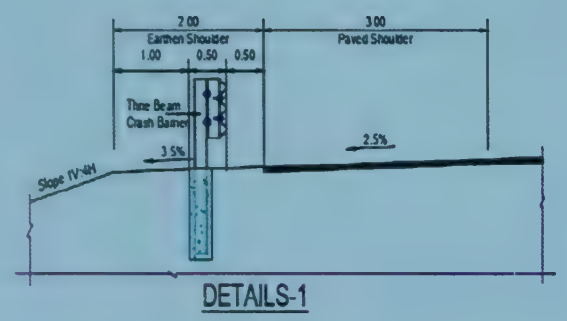
Fig. 2.1(a) Typical Cross-section of 4-Lane (2×2) Expressway in plain or Rolling Terrain with Depressed Median



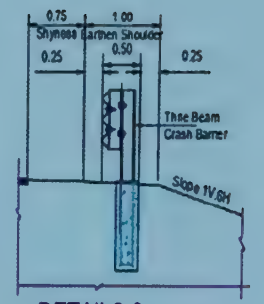
All Dimensions are in Meters

Fig. 2.1(b) Typical Cross-section of 6-Lane (2×3) Expressway in plain or Rolling Terrain with Depressed Median





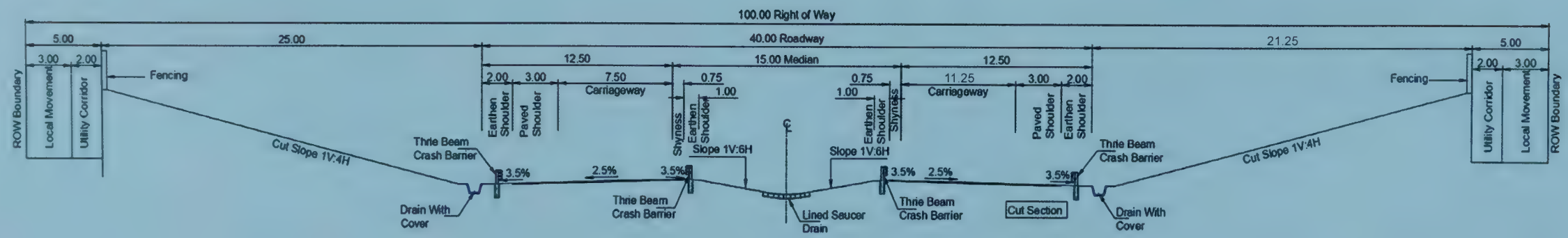
DETAILS-1



DETAILS-2

All Dimensions are in Meters

Fig. 2.1(c) Typical Cross-section of 8-Lane (2×4) Expressway in plain or Rolling Terrain with Depressed Median



All Dimensions are in Meters

Fig. 2.1(d) Typical Cross-section of 4-Lane (2×2) Expressway in plain or Rolling Terrain with Depressed Median in cut section

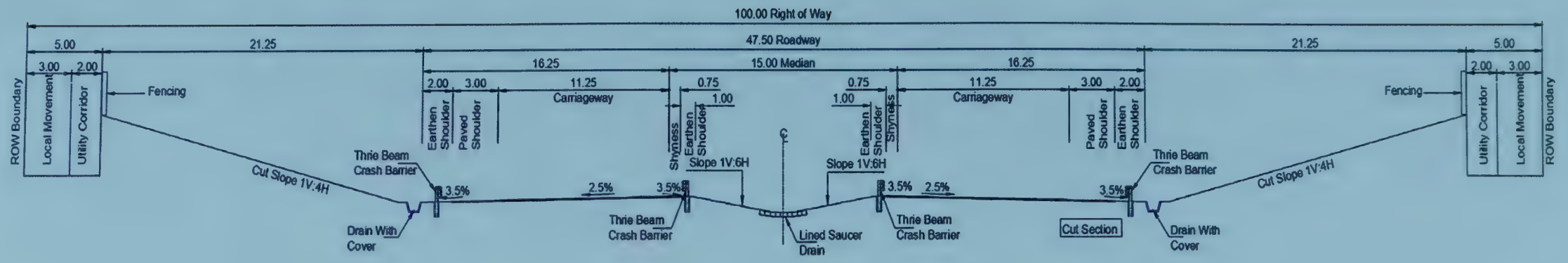


Fig. 2.1(e) Typical Cross-section of 6-Lane (2×3) Expressway in plain or Rolling Terrain with Depressed Median in cut section

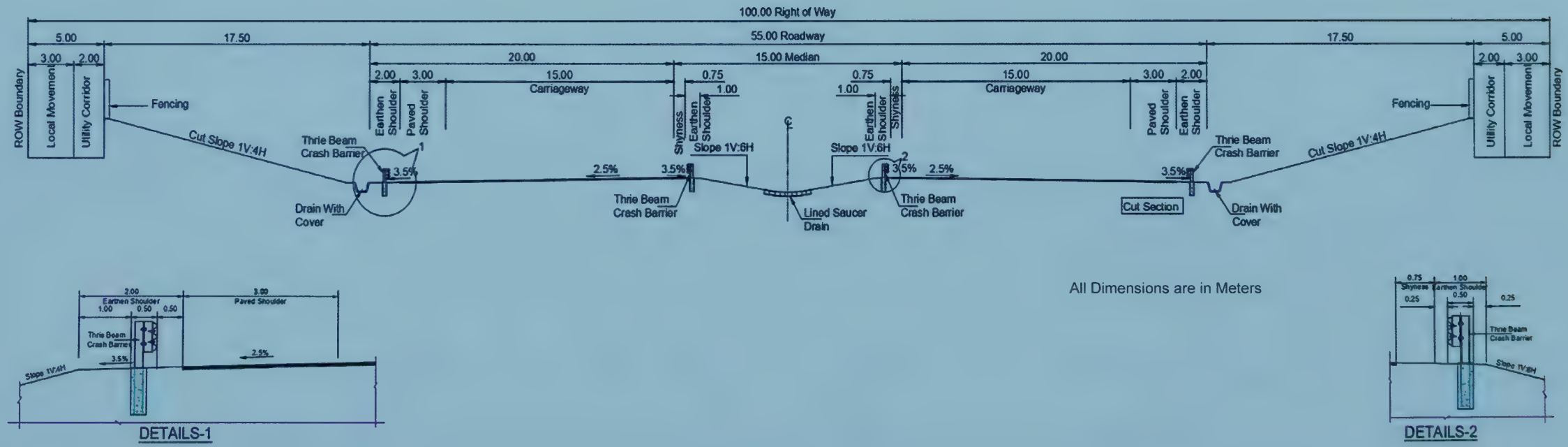
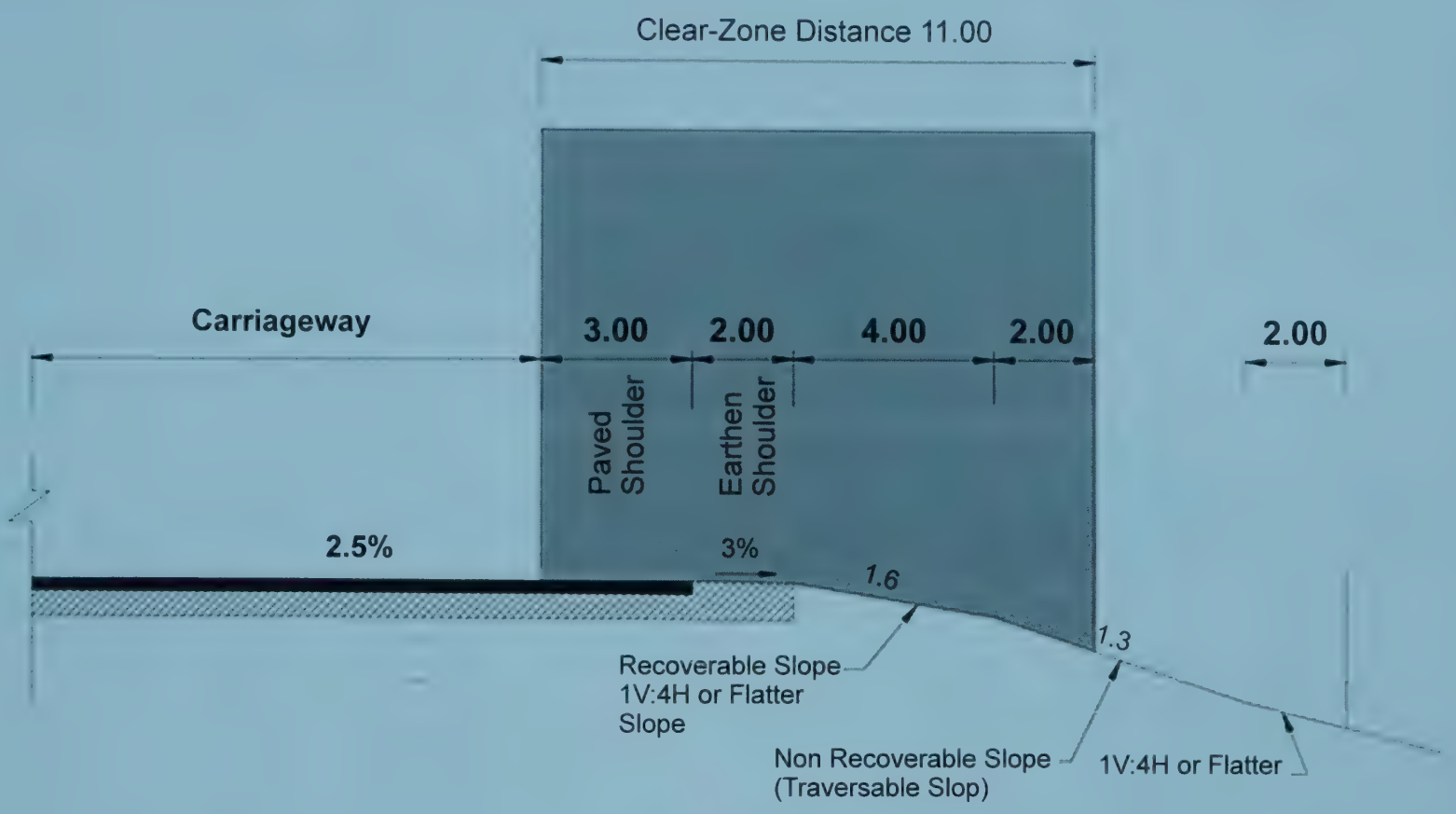


Fig. 2.1(f) Typical Cross-section of 8-Lane (2×4) Expressway in plain or Rolling Terrain with Depressed Median in cut section



*The Clear Runout Area is additional Clear-Zone Space that is needed because a portion of the Suggested Clear-Zone (Shaded Area) Falls on a Non-Recoverable Slope.

Fig. 2.2 Clear Zone

SECTION 3

GRADE SEPARATORS AND INTERCHANGES

3.1 Introduction

3.1.1 Project Expressway shall be designed for fast motorized traffic with full control of access. Access to the Expressway shall be provided with grade separators at location of intersections. Parking/standing, loading/unloading of goods and passengers and pedestrians/animals shall not be permitted on the Expressway.

3.1.2 At grade junctions are safety hazards in view of high speed after improvement/ augmentation of highways. No at grade junction is contemplated in the main carriageway of the project Expressway. As far as feasible, design of vertical profile of the main carriageway should be made keeping the vertical grade unchanged for sections having two or more cross/ check roads within about 1 Km reach.

3.2 Intersections

The intersections to be provided shall be one of the following types:

i) Grade Separators (Grade separated Intersections without ramps)

ii) Interchanges

The types and locations of Grade Separators (Grade-separated Intersections without ramps) and Interchanges shall be planned meticulously keeping in view the economy and conflict free traffic facilitation. Based on turning motion studies the interchanges such as full clover leaf, double/ single trumpet, diamond interchange, rotary interchange etc shall be decided judiciously. Requirements stipulated in MoRTH Guidelines for Expressways shall also be kept in view in this regard. These shall be specified in **Schedule B** of the Concession Agreement.

3.2.1 *Grade Separators*

The access from the Project Expressway to the cross roads in case of Grade Separators shall be through the nearest interchange.

There shall be no at-grade intersection of any road with the project expressway. The intersection of the Project Expressway with another expressway or other highway (NH/ SH) shall be through interchanges.

Fundamentally, an interchange simply provides an opportunity for traffic to transfer from one road to another. Design of an interchange is required to provide safe and efficient movement of vehicles. This allows for the greatest capacity and level-of-service that can be achieved by providing uninterrupted travel for expressway users. Naturally the type

of interchange proposed must be adequately designed to accommodate the anticipated traffic in order for the entire expressway section or segment to achieve the desired results.

3.2.1.1 Geometric standards for design

The geometric design standards for various elements of Grade Separators shall be as given in MoRTH Guidelines for Expressways except as otherwise indicated in this Manual. Gradient for approaches shall not be steeper than 2.0 percent (1 in 50).

3.2.1.2 Design of structures

Design of structures shall conform to **Section 6** of this Manual. Minimum length of viaduct required to be provided shall be specified in **Schedule B** of the Concessionaire Agreement.

3.3 Interchanges

This Manual does not envisage multi-level and directional interchanges. Where these are required the standards for these shall be set separately.

This Manual envisages only two-level interchanges for maximum four-legged intersections. Where the intersection has more than four legs, some of these have to be merged ahead of the interchange area to form a four-legged configuration. The possible layout for four-legged interchange are 'Diamond' and 'Clover Leaf' and for a three-legged interchange is 'Trumpet'. A four-legged configuration can be changed into three legged by staggering one of the legs and providing two trumpets or by providing one trumpet and an additional grade separated structure. A full clover leaf layout would require huge land area to be acquired, which may prove very expensive in most situations. Land efficiency of the interchange layout shall be one of the important considerations for making a choice of the layout.

Land efficiency of the layout can be enhanced by utilizing the land within the Interchange Area for other expressway-related functions such as locating the Traffic Management Centre, Maintenance bases, parking of O&M vehicle fleet, etc. provided three situations can be efficiently managed, viz., (i) exclusive access of the people, equipment and vehicles into the interchange area, (ii) circulation of these vehicles within the interchange area, and (iii) quick access of the maintenance and emergency vehicles from the interchange area to both carriageways of the expressway.

Spacing of the interchanges shall be around 25 km where important intersections are spaced closer than this, the straight and right turning demand shall be met by providing a grade separated under/overpass and the left turning demand for access to the expressway shall be met by constructing a new parallel link and joined to the expressway as a 'left-in-left-out' entry ramp.

Where there are no important intersecting roads within 25 km, but the development of a road network is planned, a suitable interchange location and layout shall be proposed

and shared with the development authority to align the proposed link in a manner that it seamlessly integrates with the layout so decided.

3.3.1 *Location of Interchange*

In access controlled/ partially access controlled project Expressway, VUPs/ Flyovers/ Overpasses along with Entry/ Exit Ramps/ Slip Roads/ Service Roads should be provided to cater for traffic on the cross roads. These structures will also be used by the traffic crossing over from one side to the other side of the project Expressway. When such cross over traffic is high, in particular, traffic taking U-turn at the structure, existing spans of VUP/ Flyover/ Overpass shall be provided to cater for traffic taking U-turn. The locations of individual interchanges are determined primarily to reduce detour considering regional network and nearness to places of importance. Location of interchange is guided by the following situations:

a) At crossing or nearest points of other Expressways, National Highways, State Highways and important arterial roads.

b) At crossing or nearest points of major roads to important ports, airports, material transport facilities, commercial and industrial areas, and places of tourist interest.

c) In case of overpass, no pier shall be constructed in the median. The length of superstructure (abutment to abutment) shall mandatorily be single span over the 'Roadway Width' of the Expressway. No deviation in Schedule D in this regard shall be permissible

e) The interchanges shall be provided at the locations specified in **Schedule B** of the Concession Agreement. It must be ensured in schedule B that no pier is provisioned in median.

3.3.2 *Types of Interchanges*

There are two broad categories of Interchanges, based on traffic exchange:

i) **Service Interchanges:** This refers to an interchange of the Expressway with a road less in importance than Expressway.

For this category, it is considered that Expressway shall be a toll road, and the other intersecting road shall be a "non-tolled" road or a road with open system of tolling with the toll plaza on the other road minimum 2.0 km away. This requires the consideration of tolling system which considers a barrier system as well as toll booths on the interchange ramps. This requires provision of appropriate deceleration and acceleration lanes and operating speed limitations in the interchange areas.

ii) **System Interchanges:** This refers to an interchange between two Expressways.

For this category, since both the intersecting routes are toll roads under closed system, toll booths on ramps are not required. The system needs to cater for high speed operation. The toll collection arrangements need to be considered on integrated basis between the two involved expressway stretches. The modalities need to be suitably addressed.

3.3.3 *Service interchanges*

Generally, Trumpet−type and T−type Interchanges are the preferred configuration. The advantages are;

i) Suitable for three way junction with no weaving,

ii) Limited requirement of ROW area,

iii) Single point toll plaza,

Diamond and Cloverleaf Interchanges require a number of toll plazas on entry/exit ramps, whereas Trumpet-type or T−type Interchanges require single toll plaza.

3.3.4 *System interchanges*

System interchanges are to handle high volume of traffic. The connecting ramps can be directional, semi-directional and large radius loops as well. The aspect of toll sharing between adjacent concessionaires shall be integrated. The basic forms may comprise of three legs or four legs.

For Three Leg Interchanges, the T-type configuration would require larger loops and semi directional ramps of larger radius based on traffic volumes. This may also require catering for frontage road.

For Four Leg Interchanges, the forms may be Diamond, clover leafs directional and semi directional interchanges and composite interchanges requiring combinations of straight, curved or with loops and weaving. These configurations generally require multi-level structures. **Fig. 3.1** presents illustrative service and system interchanges.

3.3.5 *Ramp types*

Ramps are provided at interchanges for desired turning movements. Based on movement requirements, the connecting ramps may be classified as Direct, Semi-direct and Loop ramps (**Fig. 3.2**).

3.3.6 *Spacing between interchanges*

Interchange spacing is based upon demand for access from the important cross roads, adequate distance to provide for signing and weaving and permit sufficient lengths of speed change lanes for respective adjacent interchange to operate safely and efficiently

at a desired level of service. For expressways, a spacing of 3.0 km is absolute minimum from deceleration, weaving and acceleration consideration. For spacing less than 3.0 km, both the interchange shall be considered as a combined one. For expressways, a spacing of 20–30 km is desirable.

Where there are no important intersecting roads within 25 km, but the development of a road network is planned, a suitable interchange location and layout shall be proposed and shared with the development authority align the proposed link in a manner that it seamlessly integrates with the layout so decided.

3.3.7 *Ramp Design Speed*

Recommended design speeds for interchange ramps are given in **Table 3.1**.

Table 3.1 Recommended design speeds for ramps

Configuration	**Type of ramp**	**Range of Expressway design speeds (km/h)**	
		100–120	**80–100**
		Range of ramp design speeds	
System Interchange	Semi-Direct	50–70	40–60
	Loop	70–90	60–80
	Direct		70–90
Service Interchange	Semi-Direct	40–60	40–60
	Loop	60–80	60–70
	Direct	60–90	60–80

3.3.8 *Ramp Width and Cross-Section*

The ramp shall have two lanes. The ramp cross-section showing carriageway width and shoulder (both paved and earthen) is given in **Fig. 3.3** for two way, two lane ramps on tangent alignment. The width of paved and earthen shoulders considered here are for interchange ramp design only. Applicable extra wide carriageway shall be provided, as needed from ramp radius consideration.

3.3.9 *Acceleration/Deceleration Lanes*

Each entry and exit ramp shall have acceleration/deceleration lane for the Project Expressway. The length of the acceleration/deceleration lanes shall be decided on the basis of speed differentials of the Project Expressway traffic and the speed permitted on the ramps.

Drivers exiting an interchange are required to reduce speed to meet with toll payment where such a scheme exists. Drivers entering an expressway from a ramp accelerate until the adjacent through lane speed is reached.

For safety, Expressway exits should be located on tangent sections, wherever possible to provide maximum sight distance and optimum traffic maneuverability operation.

Typical requirements of Acceleration length and Deceleration length and speed change length adjustment factors are presented in **Table 3.2** and **Table 3.3**. For flat grade exceeding 2.0 percent, adjustment factors given in MoRTH Guidelines for Expressways shall apply.

Table 3.2 Minimum Acceleration Lengths for entry (Grades of 2.0 percent or less)

Expressway design speed V (km/h)	Acceleration Length L (m)				
	V' speed on entry curve at A (km/h)				
	40	50	60	70	80 or more
80	145	115	65	–	–
100	285	255	205	110	40
120	490	460	410	325	245

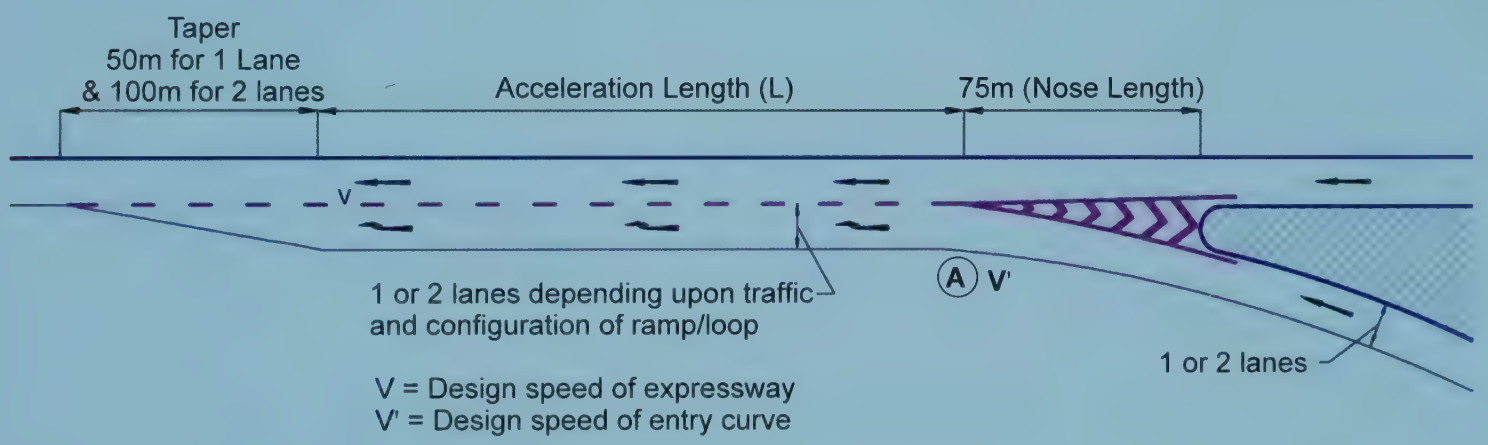
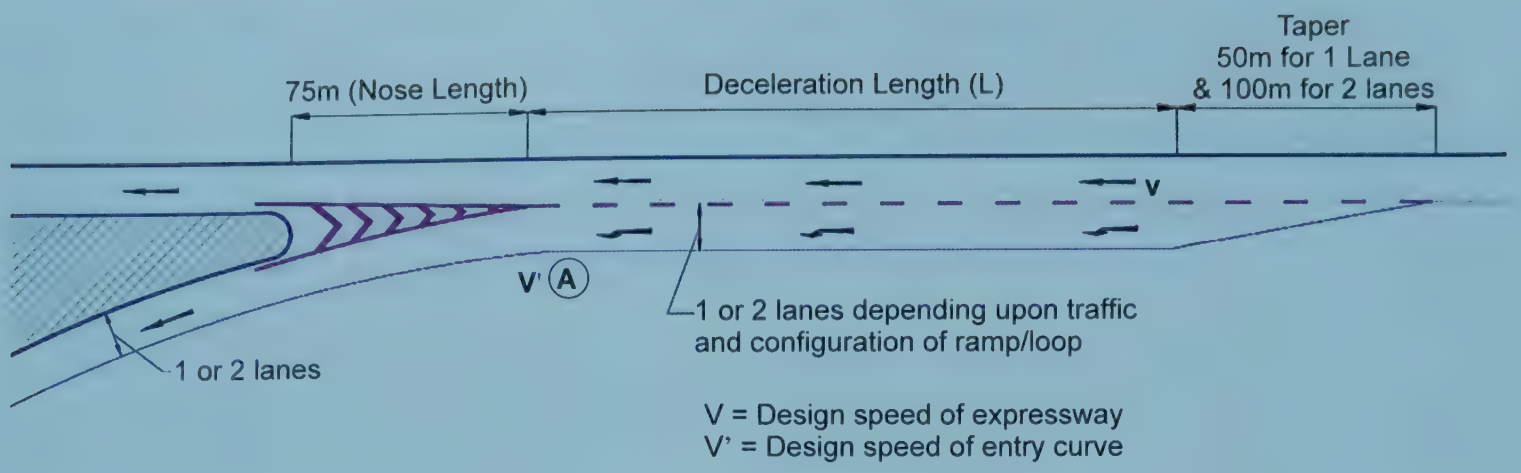


Table 3.3 Minimum deceleration Lengths for exit (Grades of 2.0 percent or Less)

Expressway design speed V (km/h)	Deceleration Length L (m)				
	V' speed on exit curve at A (km/h)				
	40	50	60	70	80 or more
80	100	90	80	55	–
100	145	135	120	100	85
120	175	170	155	140	120



3.4 Design and Data Reports

The Concessionaire shall submit the details of the ground surveys, traffic data, traffic forecast, design and drawings of the intersections and interchanges showing all safety features to the Independent Engineer for review and comments, if any.

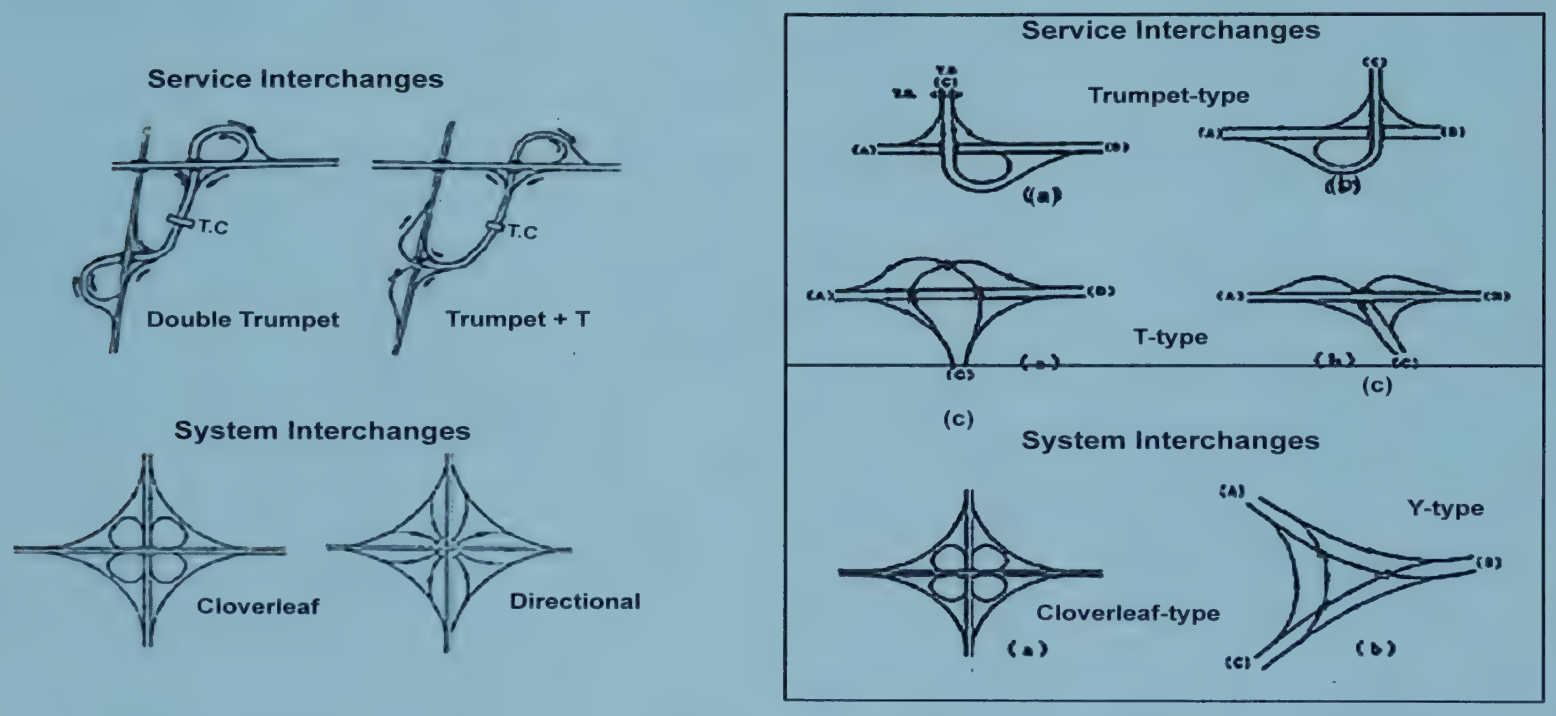


Fig. 3.1 Service and System Interchanges

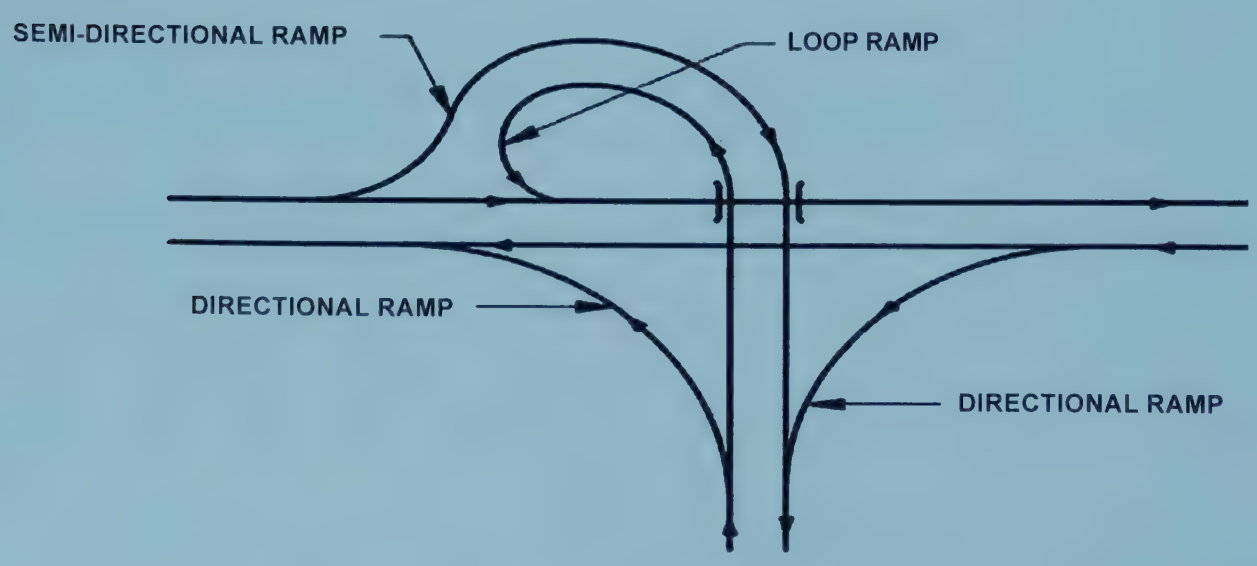
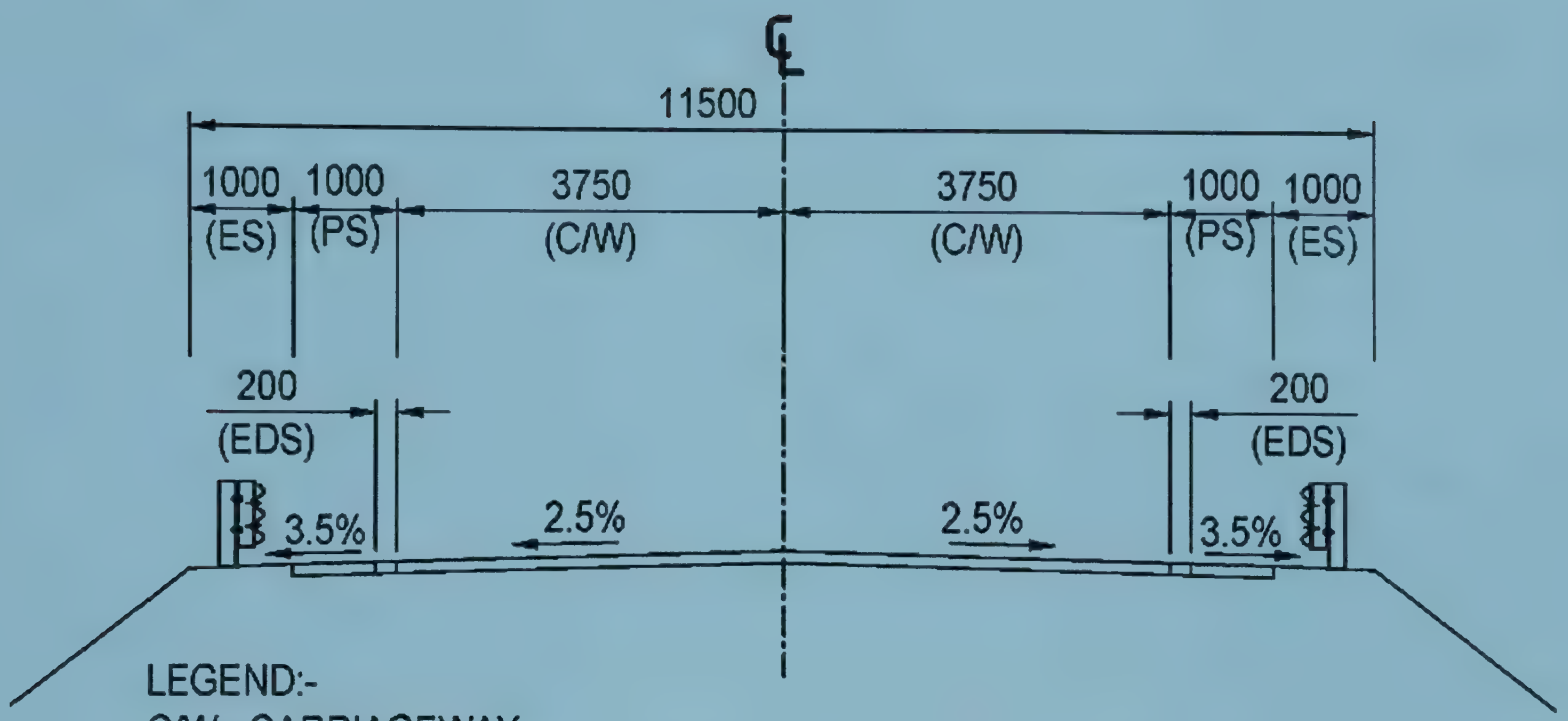


Fig. 3.2 Different Types of Ramps



LEGEND:-
C/W - CARRIAGEWAY
PS - PAVED SHOULDER
ES - EARTHEN SHOULDER
EdS - EDGE STRIP

Note: All Dimensions shown are in millimeters unless otherwise indicated

Fig. 3.3 RAMP Cross Section

SECTION 4

EMBANKMENT AND CUT SECTIONS

4.1 General

4.1.1 The design and construction of the road in embankment and in cutting shall be carried out in accordance with **Section 300** of MoRTH Specifications and the requirements, and standards and specifications given in this Section. This Section also covers specifications for subgrade and earthen shoulders.

4.1.2 The final centre line of the road and the road levels shall be fixed duly considering all the relevant factors covering structural soundness, safety and functional requirements as per relevant IRC Codes and provisions of this Manual.

4.1.3 In plain terrain, the level of the expressway will generally be controlled by drainage and earthwork considerations and can be constructed near ground level where no flooding is reported/observed and the Water Table is not high. In rolling terrain where fill material is available from cuttings, the embankment could be sufficiently raised to permit construction of underpasses without lowering the level of cross roads. The principles given in **Para 4.2** below shall be followed for fixing the height of the embankment.

4.2 Embankment

4.2.1 The height of the embankment shall be measured with respect to the finished road levels. The following principles shall be kept in view while fixing the road level:

i) No section of the road is overtopped. The top of sub-grade shall be at least 0.6 m above the general ground level.

ii) The bottom of sub-grade shall be at least 1.0 m above the High Flood Level (HFL) / level of water table/pond level. The HFL should be decided by intelligent inspections, local observations, enquiries and studying the past records. This shall be relevant to situations where road alignment is situated within the flood plains or in the vicinity of water bodies or where ponding of water is encountered and cannot be efficiently drained.

iii) To fulfill the minimum free board requirement and provide smooth vertical profile for portions forming approaches to structures.

4.2.2 *Structural Features and Design of Embankment*

4.2.2.1 To attain a natural appearance along the roadside, the side slopes should be as flat as possible and rounded. The slopes should be designed from stability considerations and to provide a reasonable opportunity for a driver to recover control of an errant vehicle.

If the right of way or other constraints make it impractical to provide recoverable slopes, it would be necessary to provide a safety barrier. Embankment slopes 1V:4H or flatter are recoverable slopes. Fixed obstacles such as culvert headwalls shall not extend above the fill slope within the clear zone distance. Embankment slopes between 1V:3H and 1V:4H are traversable but non-recoverable and a clear run-out area at the base is desirable as shown in **Fig. 2.2**.

4.2.2.2 Embankment with height 6.0 m or above shall be designed in accordance with **IRC:75** taking into account slope stability, bearing capacity, consolidation, settlement and safety considerations based on geotechnical and investigation data. Where the embankment is to be supported on a weak stratum, appropriate ground improvement measures duly approved by Independent Engineer shall be considered in the design by the Concessionaire and the cost of the same shall be borne by the Concessionaire under its Scope of work.

4.2.2.3 The side slopes and the earthen shoulders shall be protected against erosion by providing a suitable vegetative cover, kerb channel, chute, stone/cement concrete block pitching or any other suitable protection measures depending on the height of the embankment and susceptibility of soil to erosion. Drainage arrangement shall be provided as per Section 6 of this Manual. In high rainfall areas and where soil is susceptible to erosion, before providing turfing on slopes and shoulders, a coir or jute blanket shall be placed on such slopes and shoulders immediately after completion of work and in any event before onset of first monsoon after completion of work in that reach.

4.2.3 *Use of Pond Ash for Embankment Construction*

Where pond ash is used for embankment construction in pursuance of the instructions of the Ministry of Environment and Forests or otherwise, the embankment shall be designed and constructed in accordance with **IRC:SP:58**. Ministry of Road Transport & Highways' guidelines issued vide **Letter No. RW/NH-33044/01/2019-S&R(P&B) dated 23rd October 2020** (and subsequent amendments thereof) shall be followed.

4.3 Roadway in Cutting

The road level shall be fixed, keeping in view the provisions of relevant IRC Codes, and the side slopes of the cut section shall be governed by the type of soil met with. Generally, the side slopes shall be as given in **Table 4.1**. The slopes should be evaluated with regard to soil stability and potential crash severity. Desirably, the toe of the rock-cut slope should be located beyond the minimum lateral distance from the edge of the carriageway needed by the driver of an errant vehicle to either regain control or to slow down the vehicle.

Table 4.1 Slopes and cut sections

Type of Soil	Slope (H:V)
1) Ordinary Soil	3:1 to 2:1
2) Rock	½:1 to ⅛:1(depending upon quality of rock)

4.4 Soil Investigations and Design Report

4.4.1 *General*

The Concessionaire shall carry out necessary soil surveys, and field and laboratory investigations for selecting appropriate borrow pits, identifying and treating problematic ground locations, if any, and for finalizing structural features and design of the embankment and cut sections and establishing improved ground properties. A report on the soil investigations shall be furnished along with the design to the Independent Engineer.

4.4.2 *Soil investigations for embankment*

Soil investigations shall cover the following:

i) Soil investigations and tests in accordance with the requirements specified in **IRC:SP:19** and shall be reported in the Proforma given in **Table 1** of **IRC:SP:19**. In addition to this, all tests as per the requirements of MoRTH Specifications shall be reported.

ii) In respect of embankments with height more than 6 m, additional investigations and soil tests as per **IRC:75** and **Appendix 10** of **IRC:SP:19**.

iii) Information regarding the topography, high flood level, natural drainage conditions, highest sub-soil water level, and the nature and extent of inundation, if any.

iv) The characteristics of embankment foundation including the presence of any unsuitable/weak strata, marshy areas, water logged areas, etc.

v) Along the alignment of the road, where unstable strata, soft material or poor subsoil conditions have been met with at the foundation level, the soil profile shall be drawn after determining through borings, the type of soil at different levels. The borings shall be at maximum interval of 100.0 m to a depth of 2.0 m or more below the existing ground as necessary. In the case of high embankments, the borings shall be taken down to a depth equal to twice the height of the embankment.

vi) Any particular construction problems of the area or other important features.

vii) Geotechnical properties of pond ash, covering parameters specified in **Table 1** of **IRC:SP:58** and Optimum Moisture Content (OMC) – Dry Density relationship for

heavy compaction. This information shall be furnished, in case pond ash is used in embankment construction.

4.4.3 *Soil investigations for cut sections*

Soil investigations and tests shall be carried out in accordance with the requirements specified in **IRC:SP:19** and information regarding depth of water table, seepage flow, presence of any weak, unstable or problematic strata.

4.4.4 *Design Report*

The Concessionaire shall prepare the design report with all relevant details including the following:

i) Road Embankment

a) The detailed design of the embankment, remedial/ground improvement treatment where required. For embankments with height more than 6.0 m, construction methodology should also be included.

b) Design of retaining walls/reinforced earth structures.

c) Design of protection measures for embankment slope and drainage arrangement.

d) Design of pond ash embankment in case use of pond ash is proposed.

e) Any additional information relevant to the design of embankment.

ii) Cut section

a) Type of cutting involved and proposed cut slopes shall be provided in accordance with the nature of the soil encountered. Where required, benching including use of slope stability measures like pitching, breast walls, etc. shall be adopted to make the slopes stable and safe.

b) Design and details of erosion control, slope protection measures, etc.

c) In cut sections in hilly terrain, the problem of seepage flow is common. Where such conditions exist, necessary measures shall be taken including provision of deep side drains to intercept the seepage flow and discharge the drained water into suitable outlets to avoid any damage to road and cut slopes. Design and details of drainage arrangement for sub-soil and surface water shall be furnished. It should be ensured that rain water and seepage water is quickly drained out. The gradient of drain shall not be flatter than 1 in 200.

d) Any other additional information relevant to the design of cut slopes.

iii) Embankment in approaches of major bridges

Special care should be taken while designing embankment in approaches of major bridges where soil may be very poor and all the conditions of analysis such as saturation, submergence, draw down, with & without seismic effect should be applied. Due to shallow water table and weak soil, stability analysis need to be done for 3.0 m height and every 1.5 m increment till maximum height, which may be 14.0 m or more. Sub-soil and borrow area material C & Phi and bulk density values need to be tested for different layers and used in stability analysis using appropriate software such as ReSSA. Following conditions need to be applied:

a) Static loading

b) Static loading with submerged condition

c) Static loading with drawdown condition

d) Seismic loading

e) Seismic loading with submerged condition

f) Seismic loading with drawdown condition

Live Load, Factor of safety & other parameters will be checked from IRC:75. In case factor of safety is not found acceptable, than stability berms should be applied to cross section from appropriate height. Bi-axial geogrid may also be needed at ground level if bearing capacity is too less and base failure is indicated. Sinking failure also need to be checked. Designed Cross Section should also be taken care for erosions control measures. Construction need to be done not more than 1 m height per month after critical height of embankment. Construction should be done with stability berms as per requirement.

SECTION 5

PAVEMENT DESIGN

5.1 General

5.1.1 The design and construction of pavement shall be carried out in accordance with the criteria, standards and specifications given in this Section. Where alternative specifications or materials are proposed to bring in innovation in design etc., provisions of **Para 1.10 and 1.11** of this Manual shall apply.

5.1.2 The design of pavement shall take into account all relevant factors for assuring reliable performance, surface characteristics and shall satisfy the specified minimum performance requirements.

5.1.3 The Concessionaire shall undertake the necessary soil, material and pavement investigations and traffic volume and axle load studies for preparing detailed designs.

5.1.4 The materials, mixes and construction practice shall meet the requirements prescribed in the MoRTH/IRC Specifications or recognized international specifications for performance specific mixes.

5.1.5 Where problematic conditions such as expansive soils, swamps or marshes, flooding, poor drainage, frost susceptible areas etc. are found to exist, adequate measures shall be designed and adopted to deal with such site conditions. These measures shall be got approved from Independent Engineer.

5.2 Type of Pavement

5.2.1 The type of pavement to be provided shall be specified in **Schedule B** of the Concession Agreement. If nothing is specified, the Concessionaire may adopt any type (flexible/ rigid) of pavement structure for new construction of existing carriageway.

5.3 Method of Design–New Pavements

5.3.1 *Design of flexible pavement*

The pavement shall be designed in accordance with **IRC:37** "Guidelines for the Design of Flexible Pavements".

5.3.2 *Design of rigid pavement*

There are three methods of design of Rigid Pavement prescribed by IRC Codes viz. (i) IRC:58 "Guidelines for the design of Plain Jointed Rigid Pavements for Highways" (ii) IRC:101 "Guidelines for design of Continuously Reinforced Pavements and, (iii) IRC: SP:76 "Guidelines for Conventional and Thin White Topping". Rigid Pavement shall

be designed in accordance with the method prescribed in **IRC:58** "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways" unless otherwise specified in **Schedule B**.

5.4 Design Requirements for New Pavement Sections

5.4.1 *Flexible pavement-design period and strategy*

i) Pavements for Project Expressway shall be Perpetual Pavement designed as per IRC 37. Minimum base year traffic shall be provided in **Schedule B** which shall be binding on the Concessionaire

ii) Stage construction shall not be permitted.

iii) The pavement strengthening when required shall incorporate the consideration of (a) strength of existing layers as evaluated using deflection testing by FWD, (b) design period for strengthening to extend five years beyond the period of concession, and (c) specified performance requirements.

5.4.2 *Rigid pavement-design period and strategy*

Rigid pavement shall be designed for a minimum design period of 30 years. Stage construction shall not be permitted.

5.4.3 *Pavement Performance Requirements*

Pavement performance requirements for main carriageway, entry/exit ramps and acceleration/deceleration lanes shall be as follows:

i) The pavement structure shall be capable of giving the specified performance over the entire operation period.

ii) The new pavement surface shall satisfy the following standards;

a) **Surface Finish:** As per requirements of Clauses 902 and 903 of MoRTH Specifications

b) Roughness in each lane:

i) Rigid Pavement: <= 2000 mm/km for each lane in every 100m. length.

ii) Flexible Pavement: <= 1800 mm/km for each lane in every 100m length.

c) Rutting in wheel path measured by 3.0 m straight edge: NIL

d) Cracking or any other distress: NIL

iii) During the operation period, the pavement surface roughness or any structural or functional distress shall not exceed the values specified in **Schedule K** of the Concession Agreement. Periodic condition assessment surveys shall be conducted to monitor surface condition to track deterioration with time and to take appropriate timely corrective and preventive measures. Generally the pavement condition in terms of roughness, cracking and rutting should not deteriorate to the maximum values specified in **Schedule K** of the Concession Agreement for rectification, earlier than 10 years from the year of initial construction. Any treatment in the form of renewal/overlay carried out or required to restore/correct/improve the riding quality or any distress shall be of such thickness and specification that will restore the riding quality to roughness not exceeding 1800 mm/km for each lane in every 100 m length.

iv) During the operation and maintenance period, the pavement strength shall be evaluated periodically through deflection measurements (Refer to **Para 5.8** (ii) of this Section) and the stretches exhibiting any structural deficiency shall be suitably strengthened / rectified with overlays or other methods.

5.4.4 The performance of rigid pavements shall meet the requirements as specified in **IRC:SP:16 and IRC:SP:83**.

5.5 Design Traffic

5.5.1 The design traffic shall be estimated in terms of cumulative number of standard axles (8160 kg) to be carried by the pavement during the design period.

5.5.2 Initial daily average traffic flow shall be assessed based on **IRC:9**.

5.5.3 Any likely change in traffic due to future development plans, land use, shall be duly considered in estimating the design traffic.

5.5.4 The design traffic in case of entry/exit ramps and acceleration/deceleration lanes shall be same as that for main carriageway. The crust composition shall be provided accordingly.

5.6 Sub-Grade

The Sub-grade, whether in cut or fill, shall meet the requirements stipulated in **Clause 305** of MoRTH Specifications

5.7 Pavement Components and Materials

a) The pavement construction materials for sub-base, base course and bituminous surfacing shall conform to the requirements prescribed in MoRTH Specifications and IRC Standards.

b) Where several materials will adequately serve as component within the pavement structure, such as a sub-base or a base course, the concessionaire shall have the option of using any of the materials specifications, subject to specified norms and product quality requirements.

5.8 Performance Evaluation

a) Roughness in each lane for full length shall be measured twice a year using appropriate approved method and equipment.

b) The structural evaluation of the pavement shall be made by taking deflection measurements by FWD every 3 years in accordance with the procedure laid down in IRC guidelines for structural evaluation and strengthening of flexible road pavements using FWD, unless needed earlier for stretches exhibiting severe distress during the operation and maintenance period.

c) Other surface characteristics such as cracking, rutting, skid resistance shall be measured periodically at least once a year or earlier where required.

5.9 Strengthening of Existing Pavements

5.9.1 Before strengthening treatment is prescribed, a detailed pavement condition survey and evaluation shall be carried out in accordance with relevant **IRC:82** to determine.

a) The extent of distress and nature of deficiency in the existing pavement structure, and

b) Whether any special treatments e.g. provision for remedying reflection cracking, pavement internal drainage, sub-grade improvement reconstruction, or rectification of any other deficiencies are warranted.

5.9.2 Necessary corrective measures to treat the identified deficiency shall be taken along with strengthening of the pavement.

5.9.3 In stretches where the pavement is damaged/deteriorated to such an extent that the use of Falling Weight Deflectometer (FWD) may not result in a realistic assessment of the strengthening treatment, pavement shall be designed as new pavement.

5.9.4 Before implementing the strengthening treatment, the existing pavement surface profile shall be checked and if found deficient, shall be corrected by providing a suitable profile corrective course or by milling and recycling. The profile corrective course shall meet the following requirements:

a) The profile corrective course shall not form part of the overlay thickness.

b) Where the maximum thickness of profile corrective course is not more than 40 mm, it shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer.

c) Where it is to be laid as integral part of the overlay/strengthening course, the profile corrective course material shall be of the same specifications as that of the overlay/strengthening course.

5.9.5 Where an existing pavement is built over an untreated expansive/black cotton soil sub-grade, Its Improvement strengthening shall be treated separately. Such stretches shall require reconstruction with provision of necessary measures such as replacement treatment of expansive sub-grade, drainage, etc. as per the prescribed specifications and **IRC:37** and shall be designed as new pavement. Stretches to be reconstructed, whether due to sub-grade or having grossly deteriorated, etc. shall be specified in **Schedule B** of the Concession Agreement.

5.9.6 No granular layer shall be provided over an existing bituminous surfacing. Situations may arise where it is envisaged to strengthen grossly deficient existing road with a granular layer in addition to the bituminous overlay, or where for camber and/or grade correction substantial thickness of profile corrective course is needed. In such cases, the existing bituminous surfacing shall be completely removed by scarifying/milling and then the pavement built up with the granular layer(s) and bituminous overlay. The thickness and composition of bituminous surfacing (Binder course and Wearing course) over the granular layer shall conform to **IRC:37.** Removal of existing bituminous pavement shall not be necessary, if the finished road level is more than 1.0 m high from the existing bituminous surface.

5.9.7 *Rehabilitation of Pavement/overlay/Renewal*

a) The thickness of the bituminous overlay shall be determined on the basis of FWD method (**IRC:115**) and the design traffic as per the relevant code of IRC.

b) The design period will be the same as specified for the new pavement sections vide **Para 5.4.1** of this Section. Design of recycled mix where provided shall conform to the requirements of **Clause 519** of MoRTH Specifications and **IRC:120** "Recommended practice for Recycling of Bituminous Pavements.

c) The design traffic will be estimated as per the procedure described for new pavement.

5.9.8 *Bituminous mix for overlay*

a) The specifications for the bituminous mixes for the overlay shall be as specified for bituminous surfacing for new pavement sections.

b) Design of recycled mix where provided shall conform to the requirements of **Clause 519** of MoRTH Specifications and **IRC:120** "Recommended practice for Recycling of Bituminous Pavements"

5.9.9 *Pavement performance requirements and evaluation*

a) The strengthened pavement shall satisfy the minimum standard and maintenance requirements specified for new pavement sections in this Manual and **Schedule K** of the Concession Agreement.

b) The performance measurement and evaluation will be done as given in this Manual.

5.10 Paved Shoulders and Paved Median Strips

a) Paved shoulders and strip on median side shall be of same specification and composition as of new pavement of carriageway.

b) Where existing pavement /paved shoulder is proposed to be used as carriageway it shall be capable of taking design traffic load as applicable for carriageway.

c) If the thickness of the existing paved shoulders, if any, is less than the thickness of the adjacent pavement, the paved shoulders shall be re-constructed to the new pavement thickness.

d) The overlay on the main carriageway pavement and on the paved shoulders shall be uniform in thickness and composition.

5.11 Earthen Shoulders

Top 200 mm of earthen shoulder shall be well graded naturals and, moorum, gravel, crushed stone or combination thereof, conforming to **Clause 401** of MoRTH Specifications and having soaked CBR value of not less than 30%. The granular layer shall be compacted to at least 98% of the maximum dry density for the material determined as per **IS: 2720 (Part 8)**. Remaining portion shall conform to **Section 300** of MoRTH Specifications.

5.12 Construction, Workmanship and Quality of Works

All materials, construction operations, workmanship, surface finish and quality of completed construction for all pavement works including sub-grade, sub-base, base course, bituminous surface courses for both new pavement and strengthening of existing pavements, shoulders, service roads, etc. shall conform to the specified requirements and comply with the provisions of **Section 900** of the MoRTH Specifications

5.13 Premature Distress

Notwithstanding the minimum design, specifications and standards specified in the preceding paras for new pavements and strengthening of existing pavements, if the pavement shows premature distress in the form of cracking, rutting, patching, loss of camber or any other structural or functional distress, necessary remedial measures by strengthening/resurfacing/recycling shall be undertaken for conforming to the minimum requirements prescribed in **Schedule K** of the Concession Agreement. In case of repetition of the distress, reconstruction shall be resorted to after proper investigations.

5.14 Design Report

The Concessionaire shall prepare a design report and submit it to the Independent Engineer for review and comments. The pavement design proposals formulated based on the detailed investigations as required as per the relevant design Manual/Guidelines shall be submitted with the following details and other additional details specific to the type of pavement proposed.

a) Soil investigation data for new pavements as per **Table 13.2 of IRC:SP:19**. Report shall include OMC-Dry Density relationship with heavy compaction and soaked CBR values in addition to other data and information as per the prescribed Proforma.

b) Test values of aggregate for pavement courses as per **Tables 13.3 and 13.4 of IRC:SP:19**. All tests as per requirements of MoRTH Specifications shall be reported in addition to the tests and information included in the above mentioned Tables.

c) Estimation of traffic growth, axle load and VDF and traffic projections for pavement design. However, minimum base year traffic shall be provided in **Schedule B** which shall be binding on the Concessionaire

d) Any other relevant information required by the Independent Engineer for review and comments, if any.

SECTION 6

DESIGN OF STRUCTURES

6.1 General

a) All structures shall be designed in accordance with the relevant Codes, Standards and Specifications, Special Publications and Guidelines of the Indian Roads Congress. Construction of all culverts, bridges and grade separated structures shall conform to MoRTH Specifications for Road and Bridge Works.

b) Unless specified otherwise in **Schedule B** of the Concession Agreement for the 6-lane configuration of the Expressway, the structures shall be of 6-lane Standards.

c) All bridges and grade separated structures shall have independent structure for each direction of travel.

d) All bridges shall be of high level type.

e) Unless specified otherwise in **Schedule B** of the Concession Agreement for the 6-lane configuration of the Expressway, in built-up sections viaduct spans shall be provided in the approaches of the structure. However,embankment/RE wall/ Retaining wall depending on availability of ROW may be provided upto 7.5 m height. For this purpose the height shall be measured from existing road level to top of sub grade.

f) The median in the portion of structures shall be treated as below:

   i) A suitably designed catch pit shall be provided to collect and carry discharge from median drain.

   ii) The median shall be open to sky. The safety barrier on the median side shall be provided at a clear distance of 0.5 m from the edge of carriageway.

g) The width of median in the culvert and bridge portion shall, as far as possible, be kept same as that in the approaches. In case width of median is different from that of approach section due to site constraints, transition of 1 in 50 shall be provided near approaches for guiding vehicular traffic.

h) Suitable provision shall be made for retaining the earth in the median portion either by extending the abutment wall or constructing a new retaining wall. The abutment wall shall have provision for taking the discharge from the median.

i) Provision of water pipeline, electricity accessories and Gas line etc. shall not be allowed on the structures.

j) Provision for any other utility service such as OFC & telephone cable to be carried by the structures shall be made in the design as per relevant circular of MoRTH.

6.2 Design Loads and Stresses

a) The design loads and stresses shall be as per **IRC:6** appropriate for the width of carriageway, velocity of stream, location, altitude, environment, etc.

b) All structures shall be designed for the condition when paved shoulder and edge strip on median side is also used as carriageway. No footpath shall be provided on the bridge carriageway along the Expressway.

c) All the components of structures shall be designed for a service life of 100 years except appurtenances like crash barriers, wearing surface and rubberized components in expansion joints and elastomeric bearings. All the requirements to achieve durability and serviceability shall be implemented during design, construction and maintenance.

6.3 Width of Structures

Width of the culverts, bridges and grade separated structures shall be adopted as below:

i) Culverts

a) The pipe culverts shall extend up to a distance of clear zone as defined in **Section 2** of this Manual, on either side of carriageway. The side slopes at the culvert shall be same as of the adjoining embankment and may be achieved by reducing the cushion over pipe.

b) For the slab and box type culverts, the outer face of the left crash barrier on the structure shall be in line with the outer edge of the earthen shoulder. On the inner side, the culvert shall extend upto full width of median. Joint between the structures of two sides may be provided at the middle of median.

c) The slope of the adjoining embankment shall be suitably graded to merge with the top level of culvert with longitudinal slope not steeper than 6H: 1V.

Cross-section of the pipe culverts for a 4/6/8 lane expressway are given in **Figs. 6.1(a)** , **6.1(b)** and **6.1(c)** respectively for depressed median.

Cross section of the slab and box type culverts for a 4/6/8 lane expressway are given in **Figs. 6.2 (a) , 6.2(b) and 6.2(c)** respectively for depressed median.

ii) Bridges and Grade Separated Structures / ROBs

a) The overall width of structures shall be such that the outer face of left crash barrier on the structure is in line with the outrage of earthen shoulder and in side crash barrier is located at a clear distance of 0.75 m from the edge of the outer most carriageway of adjoining road (the paved edge strip of 0.75 m on median side shall continue on the structure also.

b) Cross section of bridges and grade separated structures for a 4/6/8-lane expressway for one side are given in **Figs. 6.3(a), 6.3(b)** and **6.3(c)** respectively for depressed median.

c) In case of ROBs, steel wire fencing of length equal to span of ROB and height not less than 1.5 m over the concrete crash barrier shall be provided on both sides of railway span.

6.4 Structure Types

The Concessionaire may choose any type of structure and structure system commensurate with span arrangements as detailed in Schedule B and para D, safety, serviceability and durability requirements. The general guidelines as below shall be followed:

i) The structure should aesthetically blend with the environment.

ii) The type and span arrangement may be such as to provide maximum riding comfort and involve minimum inspection and maintenance during the service life of structure.

iii) Continuous superstructure with fewer numbers of bearings and expansion joints if not unsuitable otherwise should be preferred over simply supported spans.

iv) For minor bridges and culverts integral concept (in which sub-structures and superstructure are made joint less i.e. monolithic) is preferred.

v) Wherever box girders are proposed for superstructure, the minimum clear depth inside the box shall be 1.50 m with suitable openings in the diaphragms and box to facilitate inspection. Haunches of minimum size of 300 mm (horizontal) and 150 mm (vertical) shall be provided at the extreme corners of the box section. Suitable arrangements for lighting shall be made to enable inspection of the box.

vi) The following types of structures shall not be accepted.

   a) Drop in spans with halved joints (articulations)

   b) Trestle type frames for substructures

vii) In case of special structures such as cable stayed, cable suspension, extra dose and bridges with specific design technology is envisaged, it shall be specified in **Schedule B** of the Concession Agreement. The same shall be mandatorily followed without any alternative. Similarly, in case minimum span length, spacing between joints, obligatory span(s), etc are desired, the same shall be specified in **Schedule B** and same shall be obligatory and followed.

viii) In case span length is specified in **Schedule B** of the Concession Agreement, the Concessionaire shall have option to adopt larger span length but not reduce

them. The change in span length as above shall not be treated as change in scope provided the total length of structure is not less than that specified in **Schedule B** of the Concession Agreement.

ix) Concepts that involve precast elements are preferable for improved quality, better finish and reduction of environmental impact.

x) When the alignment crosses urban environment, the construction methodology should be such as to avoid prolonged disturbance to existing traffic.

xi) In built up areas, 'Noise Barriers' over the structures shall be provided.

6.5 Hydrology

All the structures shall have adequate waterway, which shall in any case be not less than that of existing bridge (except when such waterways can be reduced in cases like clogging or silting of spans, etc.). The design discharge shall be evaluated for flood of 100 year return period. Navigational clearance (horizontal and vertical) wherever required shall be ensured in consultation with the river authority/IWAI.

6.6 Sub-Soil Investigations

6.6.1 The Concessionaire shall carry out Independent sub-soil investigations to establish the soil parameters required for detailed design of foundations in accordance with relevant provisions of **IRC:78** and MoRTH Specifications.

6.6.2 For single span structures (bridges, over passes, ROBs etc.), bores shall be taken at each of the abutment locations. For structures having more than one span, at least one bore shall be taken at each of the foundation locations. However, for structures having smaller spans, the spacing between two bore holes may be kept as 10-12 m.

6.7 Culverts and Bridges Using Pipes

i) Reinforced concrete pipes for culverts and bridge structures shall be of Non Pressure (NP) - 4 type conforming to the requirements of **IS:458**.

ii) Minimum diameter of pipes for new pipe culverts shall be 1200 mm.

6.8 Temporary Works

6.8.1 *Formwork*

The Concessionaire shall be responsible for the safe, workable design and methodology for all temporary or permanent forms, staging and centering required for supporting and forming the concrete of shape, dimensions and surface finish as shown on the drawings (Refer **IRC:87**). Adequate foundation for the staging shall be ensured. Redundancy in support system shall also be ensured by providing diagonals and additional members.

The following guidelines shall be adopted:

i) Formwork shall be of steel, marine ply or laminated plywood.

ii) Only such shuttering oil (release agent) shall be used, which permits easy removal of shutters without leaving stains or other marks on the surface of the concrete. Requirements given under **Clause 3.5 of IRC:87** shall also be complied with.

iii) In case of tubular staging special attention shall be paid to the structural adequacy of the system, efficancy of the connections (clamps etc.), and foundations. Foundation blocks of adequate thickness in M-15 cement concrete shall be provided under the base plates to prevent differential settlements. All bent tubular props shall be straightened before re-use and the member with deviation from straightness more than 1 in 600 of its length shall not be re-used. For re-used props, suitable reduction in the permissible loads shall be made depending upon their condition in accordance with recommendations of the manufacturer and as reviewed by the IE.

iv) In case of pre-stressed concrete members, the side forms shall be removed as early as possible and the soffit forms shall permit movement of member without restraint; when pre-stress is applied. Form supports and forms for cast-in-situ members shall not be removed until sufficient pre-stress has been applied to carry all anticipated loads during construction stage.

v) Adequate foundations for formwork shall be ensured.

6.8.2 *Special temporary and enabling works*

Designs, drawings and methodology proposed by the Concessionaire in the use of special temporary and enabling works like Launching Girders, Cantilever Construction Equipment, Tall Formwork, Shoring for Earth Retention, Lifting and Handling Equipment's and the like shall be submitted to the Independent Engineer (IE) for his review and comments, if any. The Concessionaire shall be fully responsible for the design and structural adequacy of all temporary and enabling works. Review by the IE shall not relieve the Concessionaire of this responsibility.

6.8.3 The construction methodology adopted by the Concessionaire should ensure speedy and safe construction including safety of workers.

6.9 Foundations and Sub-Structures

6.9.1 The design of foundations and sub-structures shall conform to **IRC:78**.

6.9.2 *Open foundations*

The design of open foundations shall conform to **IRC:78**. Floor protection shall be provided as per **Section 2500** of MoRTH Specifications.

6.9.3 *Pile foundations*

The design of pile foundations shall be done as per **IRC:78**. Initial load test shall invariably be done on at least two piles for each structure before starting piling work. However for structures of length less than 60 m length, the initial load test may be done on at least one pile.

6.9.4 *Well foundations*

The design of well foundations shall be done as per **IRC:78**.

6.9.5 *Raft Foundation*

For design of raft foundation Guidelines for the design and construction of Raft foundation for road bridges guidelines given in **Appendix 8 of IRC:78** be adopted

6.10 Approach Slabs

Approach slabs shall be provided for all bridges and grade separated structures as per **Clause 217 of IRC:6** and **Section 2700** of MoRTH Specifications.

6.11 Superstructures

6.11.1 The design of reinforced and pre-stressed concrete superstructures shall be as per **IRC:112**. The design of steel and steel-concrete composite super structures shall conform to **IRC:24** and **IRC:22** respectively.

6.11.2 The Concessionaire shall submit the method statement to Independent Engineer for review and comments, (For EPC, for approval of Authority Engineer) if any, indicating inter-alia the following

i) Sources of materials,

ii) Design, erection and removal of formwork,

iii) Layout of casting yard together with necessary details,

iv) Production, transportation, laying, compacting and curing of concrete,

v) Sequence of concreting in cast-in-situ construction, side shifting of girders, if applicable and placing of girders on the bearings.

vi) Details of construction joints

vii) Pre-stressing system, if required,

viii) Methodology and equipment for side shifting and launching of pre-cast girders,

ix) Key personnel for execution and supervision,

x) Testing and sampling procedure,

xi) Equipment details.

6.12 Bearings

6.12.1 All bearings shall be easily accessible for inspection, maintenance and replacement. Suitable permanent arrangements shall be made for inspection of bearings from bridge deck. Design and specifications of bearings shall be as per **IRC:83 (Part I, II, III & IV)**. Spherical bearings shall conform to the requirements of **BS:5400**. The materials of such bearings may conform to the relevant BIS codes nearest to the specifications given in **BS:5400**. The drawing of bearings shall include the layout plan showing exact location on top of pier and abutment cap and the type of bearings i.e. fixed/free/rotational at each location along with notes for proper installation. The bearing should cater for rotation and movement in both longitudinal and lateral direction.

6.12.2 The above stated codes/ guidelines categorically stipulate the functional requirements, specifications, properties of various materials to be used for manufacturing of the bearing/ expansion joints, dimensions, acceptance criteria, testing, installation, inspection, maintenance, replacement etc. for bearing/ expansion joints. Moreover, the manufacturer / supplier has to furnish a complete Quality Assurance Program comprising the process of quality control, raw material testing, various stages of manufacturing, complete testing etc. in conformity with relevant codal stipulations. The said Quality Assurance Program shall be approved by the Engineer I Accepting Authority.

6.12.3 The requirement of Supplier/ Manufacturer and their selection for Bearings and Expansion Joints, the role/ responsibilities of various stake holders shall be as detailed in MoRTH Circular dated 14th August, 2018 (Guidelines and Standard Operating Procedure for selection of manufacturers/Suppliers of various types of bearings and expansion joints for bridges on National Highways and other centrally sponsored schemes) and subsequent modifications thereof.

6.13 Expansion Joints

6.13.1 The Expansion joints should cater for movement in both longitudinal and lateral direction. Structures shall have minimum number of expansion joints. This may be achieved by adopting longer spans, making the superstructure continuous or by adopting integrated structures having minimum distance of 100 m. between to expansion joints. Expansion joints shall conform to **IRC:SP:69**. The Concessionaire shall furnish guarantee/proprietary indemnity bonds from the manufacturers/suppliers of expansion joints for a period of 10 years.

6.13.2 The above stated codes/ guidelines categorically stipulate the functional requirements, specifications, properties of various materials to be used for manufacturing of the bearing/ expansion joints, dimensions, acceptance criteria, testing, installation, inspection,

maintenance, replacement etc. for bearing/ expansion joints. Moreover, the manufacturer/ supplier has to furnish a complete Quality Assurance Program comprising the process of quality control, raw material testing, various stages of manufacturing, complete testing etc. in conformity with relevant codal stipulations. The said Quality Assurance Program shall be approved by the Engineer I Accepting Authority.

6.13.3 The requirement of Supplier/ Manufacturer and their selection for Bearings and Expansion Joints, the role/ responsibilities of various stake holders shall be as detailed in MoRTH Circular dated 14th August 2018 (Guidelines and Standard Operating Procedure for selection of manufacturers/Suppliers of various types of bearings and expansion joints for bridges on National Highways and other centrally sponsored schemes) and subsequent modifications thereof .

6.14 Wearing Coat

i) The wearing coat may be either bituminous or cement concrete type. The wearing coat shall have unidirectional camber and shall be in conformity with **Section 2700** of MoRTH Specifications.

ii) Wearing coat older than 15 years or in damaged/distressed condition shall be replaced even though it is not specified in **Schedule B**.

6.15 Reinforced Earth Retaining Structures

6.15.1 The design of Reinforced earth retaining structures shall be as per **IRC:SP:102**. Reinforced earth retaining structures should be given special attention in design, construction, ground improvement where necessary, maintenance and selection of System/System design. Local and global stability of the structure shall be ensured. However, such structures shall not be provided near water bodies. The specification of RE structures shall conform to **Section 3100** of MoRTH specifications.

6.15.2 Design Accreditation and warranty for life of the structure from the approved supplier/ manufacturer shall be obtained and furnished. A qualified and experienced technical representative of the approved supplier/manufacturer shall be present on site throughout during the casting and erection phases to ensure that the quality of the works executed by the Concessionaire is in accordance with good industry practice.

6.15.3 The Concessionaire shall submit relevant information on the system covering inter-alia the following:

i) General features of the system along with specifications and standards;

ii) Authenticated copies of license/agreement, if any;

iii) Details of plant and equipment to be used along with the names of manufacturers and name of process/system;

iv) Details of projects where the process/system has been successfully used;

v) Limitations, if any;

vi) Acceptance tests and criteria;

vii) Installation and maintenance procedure and schedule; and

viii) Performance warranty.

6.15.4 The Concessionaire shall submit a method statement including the following:

i) Design assumptions calculations and drawings,

ii) Construction Procedure,

iii) Tests to be conducted including frequency and the formats for reporting the test results.

6.15.5 The packaging of reinforcing elements shall clearly indicate the name of the manufacturer/ supplier and brand name, date of production, expiry, if any and batch identification number along with the manufacturers test certificates.

6.16 River Training and Protective Works

River training and protective works shall be provided wherever required for ensuring the safety of bridges and their approaches on either side. The design of various types of river training and protective works shall be in accordance with **IRC:89**. The construction of river training works shall conform to MoRTH specifications

6.17 Safety Barriers

i) For bridges, concrete crash barriers shall be provided at the edge of the carriageway on all new bridges.

ii) The type design for the crash barriers may be adopted as per IRC:5. The design loading for the crash barriers shall be as per Clause 209.7 of IRC:6.

iii) Crash barriers on the structures shall be suitably continued and connected with safety barriers on approaches on either side of the structures to have smooth transition as per guidelines given in **Section 10** of this Manual.

6.18 Rail-Road Bridges

6.18.1 ROB/RUB to be provided shall be as specified in this Manual, with particular reference to the provisions of **Para 6.3** of this Section. Any deviation to these provisions shall be specified in **Schedule D**.

6.18.2 *Road Over Bridge (Road Over Rail)*

In case the bridge is to be provided over an existing level crossing, twin 3-lane bridges shall be constructed with overall width as given in **Sub Para 6.3** (ii) of this Section. If the alignment of road at the existing railway crossing has skew angle more than 45 degrees, the alignment of road or of pier/abutment shall be suitably designed to reduce skew angle up to 45 degrees.

The horizontal and vertical clearances to be provided shall be as per requirement of the Railway authorities.

The Authority shall provide General arrangement Drawing (GAD). The Concessionaire shall be responsible for obtaining approval of all designs and drawings from the concerned Railway Authorities, in accordance with relevant Railway Codes.The Authority shall not be responsible for any delay and consequent liability beyond making available of the GAD. The construction of ROB within the railway boundary shall be under the supervision of Railway authorities.

The approach gradient shall not be steeper than 1 in 50.

6.18.3 *Road Under Bridges (Road Under Railway Line)*

i) Full roadway width as in the approaches shall pass below the bridge structure.

ii) The vertical and lateral clearances shall be as per guidelines given in **Section 2** of this Manual.

iii) These structures shall be designed to carry railway loads. The Authority shall provide General arrangement Drawing (GAD). The Concessionaire shall be responsible for obtaining approval of all subsequent designs and drawings from the concerned Railway Authorities, in accordance with relevant Railway Codes. The Authority shall not be responsible for any delay and consequent liability beyond making available of the GAD.

iv) The construction of RUB and its approaches shall be carried out in conformity with the terms specified in the approval granted by the Railway authorities. The construction of ROB within the railway boundary shall be under the supervision of Railway authorities

6.18.4 In cases of ROB, the service road on both the sides shall be joined through one of the viaducts of ROB. This arrangement shall be on either side of the railway crossing

6.19 Grade Separated Road Structures

i) The location, type and length of grade separated structures to be provided on the Expressway shall be as specified in **Schedule B** of the Concession Agreement.

ii) The vertical and lateral clearances shall be as per requirements given in **Section 2** of this Manual. Design of structures shall conform to requirements specified in this Manual. A typical cross-section of a grade separated structure/ elevated section is given in **Fig.6.3**.

6.20 Drainage

An effective drainage system for the bridge deck shall be planned, designed and installed so as to ensure that water from the deck is taken down to ground level/drainage courses by adequate size of drainage spouts and pipes. Guidelines for drainage given in **Section 9** of this Manual shall be adopted.

6.21 Structures in Marine Environment

Necessary measures/treatments for protecting structures in marine environment shall be carried out by the Concessionaire as per relevant Indian standard Codes, at part of his scope of work at his own cost.

6.22 Design Report

The Concessionaire shall furnish the design report, including the following, to the Independent Engineer for his review and comments, if any.

i) Sub soil exploration report as per **IRC:78**.

ii) Hydrological Investigation report including hydraulic design in respect of design discharge for the bridges and culverts, waterway, afflux if any, scour depth, design HFL, etc.

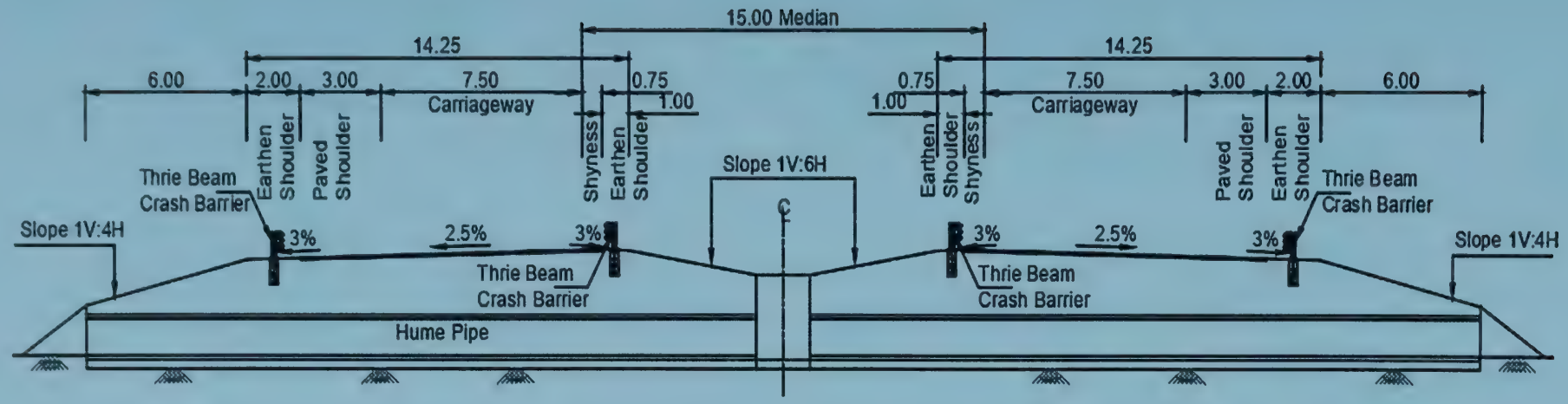
iii) Detailed designs and drawings of temporary works, foundations, substructures and superstructure of structures and appurtenances.

iv) GAD and preliminary design proposal for future widening to 8-lane configuration.

v) Any other information relevant to the design of structures.

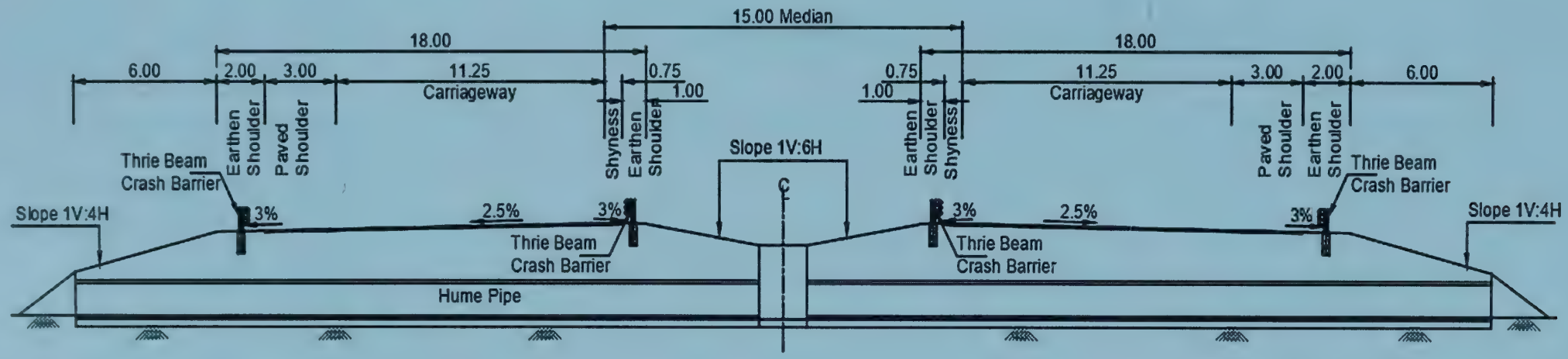
6.23 Responsibility for Design and Structural Adequacy

The Concessionaire shall be fully responsible for the design, structural adequacy and detailing of bridge and culvert structures. Review by IE, (For EPC, approval by Authority Engineer) shall not relieve the Concessionaire of this responsibility.



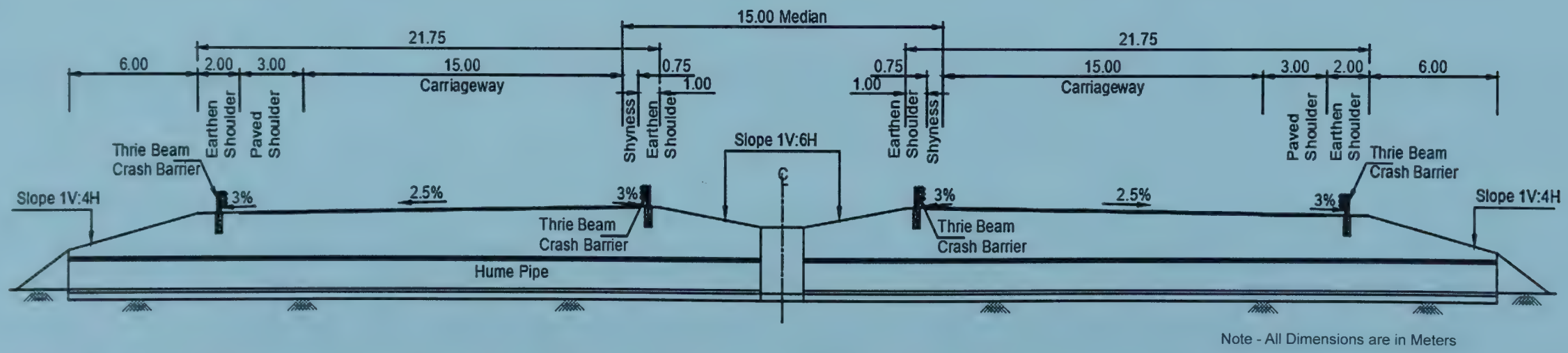
Note - All Dimensions are in Meters

Fig. 6.1(a) Typical Cross-section of Pipe Culvert for 4-Lane (2×2) Expressway with Depressed Median



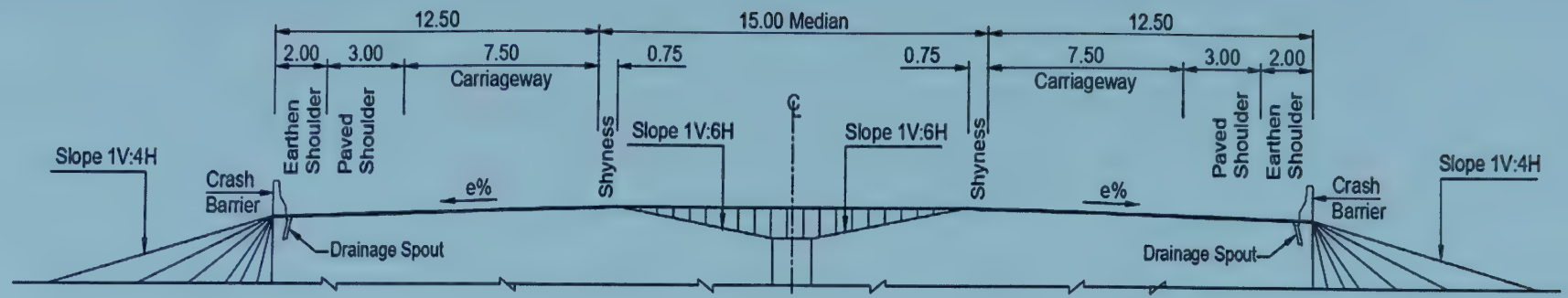
Note - All Dimensions are in Meters

Fig. 6.1(b) Typical Cross-section of Pipe Culvert for 6-Lane (2×3) Expressway with Depressed Median



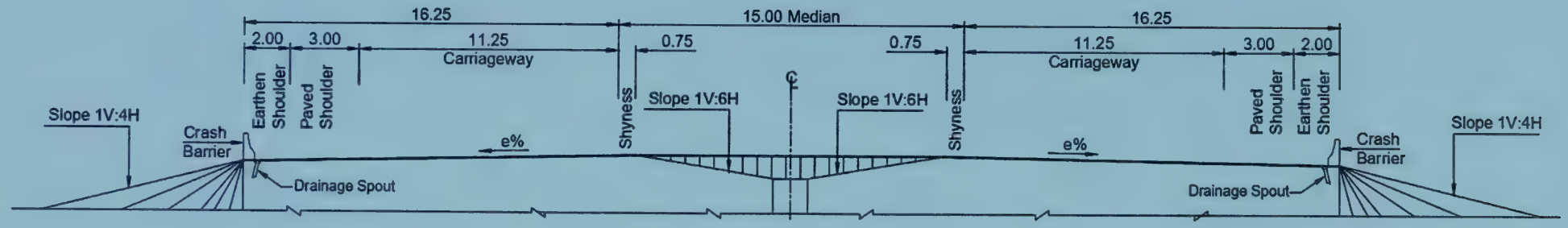
Note - All Dimensions are in Meters

Fig. 6.1(c) Typical Cross-section of Pipe Culvert for 8-Lane (2×4) Expressway with Depressed Median



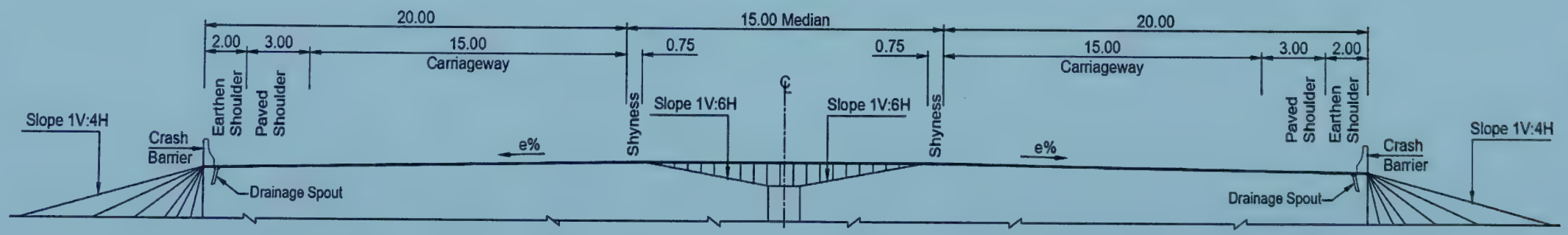
Note - All Dimensions are in Meters

Fig. 6.2(a) Typical Cross-section of Slab and Box type Culvert for 4-Lane (2×2) Expressway with Depressed Median



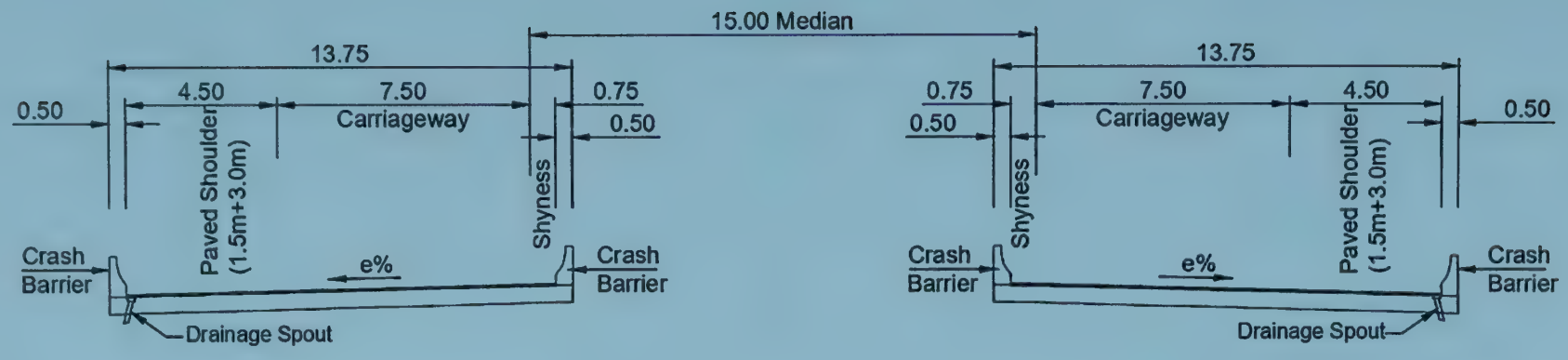
Note - All Dimensions are in Meters

Fig. 6.2(b) Typical Cross-section of Slab and Box type Culvert for 6-Lane (2×3) Expressway with Depressed Median



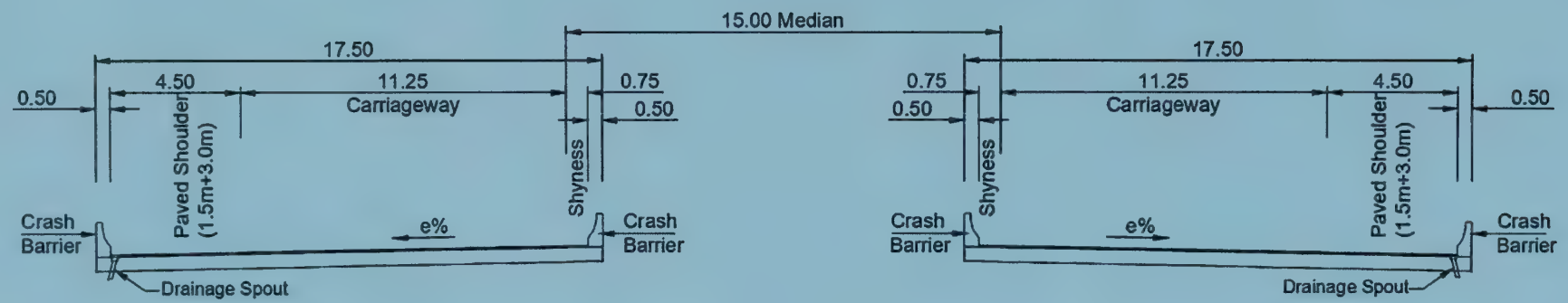
Note - All Dimensions are in Meters

Fig. 6.2(c) Typical Cross-section of Slab and Box type Culvert for 8-Lane (2×4) Expressway with Depressed Median



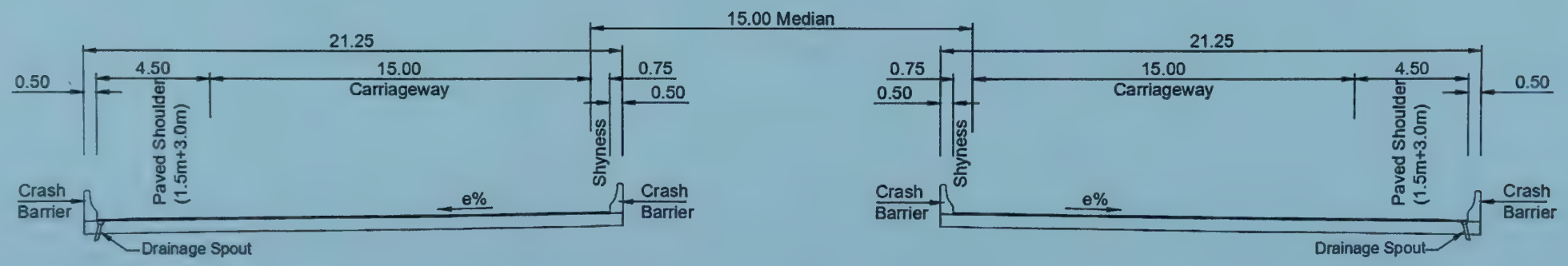
Note - All Dimensions are in Meters

Fig. 6.3(a) Typical Cross-section of 4-Lane (2×2) Bridge and Grade Separated Structure



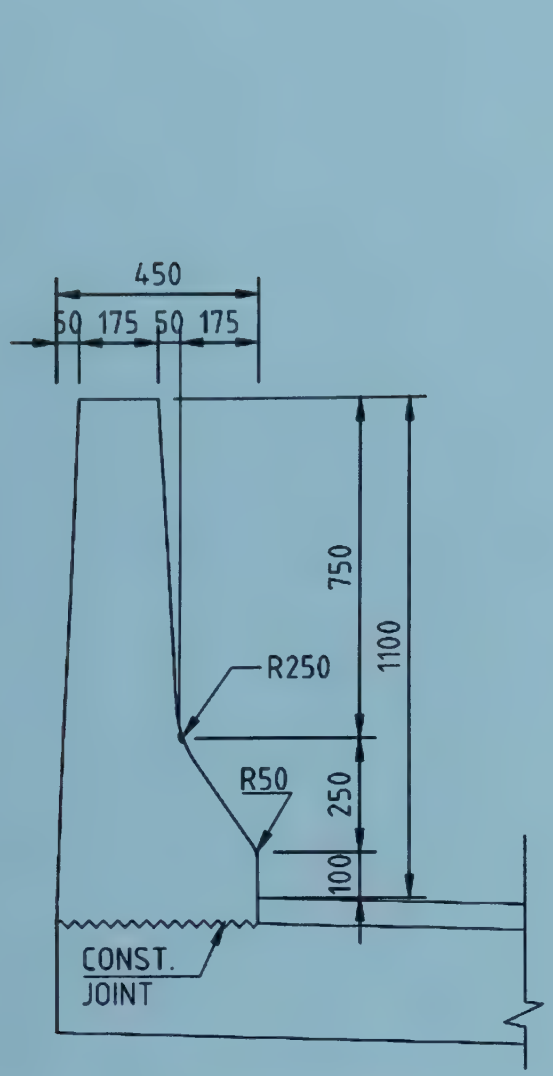
Note - All Dimensions are in Meters

Fig. 6.3(b) Typical Cross-section of 6-Lane (2×3) Bridge and Grade Separated Structure

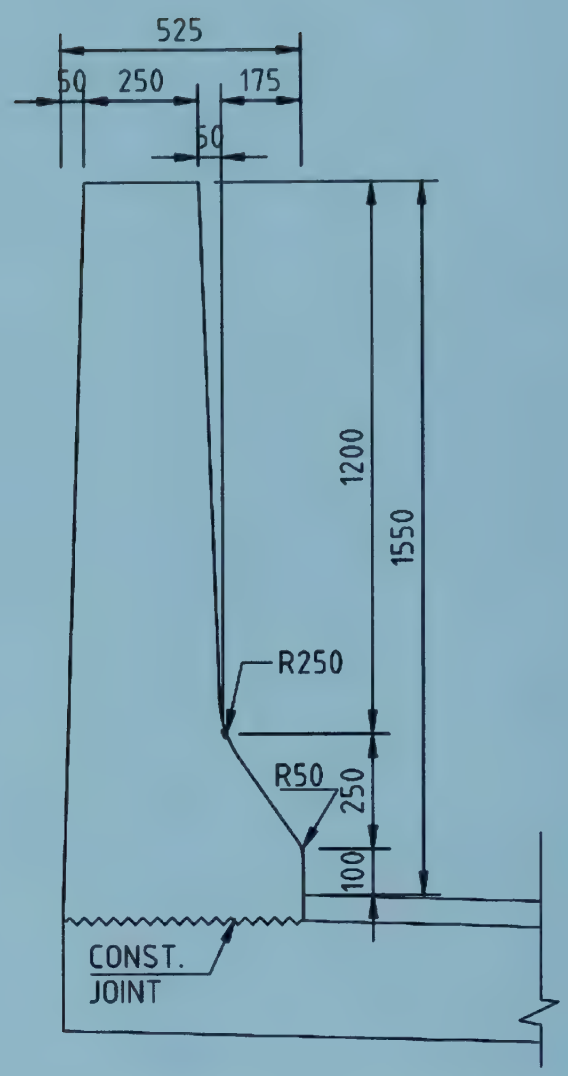


Note - All Dimensions are in Meters

Fig. 6.3(c) Typical Cross-section of 8-Lane (2×4) Bridge and Grade Separated Structure



(a) Vehicle Crash Barrier



(b) High Containment Crash Barrier

Note - All Dimensions are in Millimeters.

Fig. 6.4 Typical Details of Crash Barriers (extracts from IRC:5).

SECTION 7

TUNNELS

7.1 General

7.1.1 Expressway shall be constructed in tunnel either to carry the alignment under or through a natural obstacle or to minimize the impact on the community under conditions such as:

i) Long, narrow mountainous terrain where a cut section is economically unviable or leads to adverse environmental consequences.

ii) Narrow right-of-way where all the surface area must be retained for road purpose.

iii) Railway yard, airport or similar facilities.

iv) Parks or other land uses, existing or planned.

v) Prohibitive costs of land acquisition exceeding the costs of tunnel construction and operation.

7.1.2 Planning and design of tunnel shall be based on various conditions along the expressway alignment including the topography, geology, meteorology, environment, locations and traffic volumes and shall generally conform to provisions of **IRC:SP:91** and this Manual.

7.1.3 Wherever tunnel is required to be provided, its location, length and number of lanes shall be indicated in **Schedule B** of the Concession Agreement.

7.2 Geometrics

7.2.1 A tunnel shall have the same geometric standards as on the expressway carriageway outside the tunnel except as specified in this Section.

7.2.2 *Cross section*

Shape of tunnel cross section shall be commensurate with the methodology of construction, e.g., mining or cut-and-cover method, geotechnical conditions and structural consideration.

7.2.3 *Horizontal clearance*

The tunnel shall cater for carriageway, paved shoulder, edge strip as on the adjoining carriageways outside the tunnel, and space to be provided for ventilation ducts, escape footway, emergency lay-bye where necessary, lighting, drainage, fire and other services.

7.2.4 *Vertical clearance*

The tunnel shall have a minimum vertical clearance of 5.5 m over the full width of carriageway and paved shoulders. Vertical clearance over footway shall be 3.0 m minimum. Additional

vertical clearance shall be provided for accommodating tunnel ventilation lighting fixtures and overhead traffic signs.

7.2.5 *Number of traffic lanes*

For Project Expressways up to 8-lanes, twin tubes of 3-lane configuration shall be provided.

7.2.6 *Carriageway and Paved shoulder*

The carriageway of the Tunnels shall be of cement concrete. Tunnels shall have paved shoulder of 3.0 m on left side and edge strip of 0.75 m on the right side. In case of tunnels having more than 500 m length, provision shall be made for 100 m long and 3.0 m wide emergency lay bye beyond the left most lane at 750 m intervals to facilitate refuge for break down/damaged vehicles and also for maintenance vehicles. Proper transitions, line of sight and informatory signs shall be ensured for such lay-bye.

Typical tunnel cross sections for unidirectional traffic conditions for three-lane carriageway configurations are given in **Fig. 7.1** for cut and cover type construction and in **Fig. 7.2** for mining type construction. A typical layout of lay-bye is shown in **Fig. 7.3** for tunnels of length more than 500 m.

7.2.7 *Tunnel spacing*

The clear distance between the twin tubes shall be kept depending upon the type of strata and structural stability of the tunnel. Guidance in this regard may be taken from **IRC:SP:91** or any specialist literature.

7.2.8 *Tunnel passage*

The twin tunnels of more than 500 m length shall be connected by a cross passage at an inclination to facilitate diversion of the traffic from one tube to other tube in the event of an incident/accident in one of the tubes at a spacing of 300 m. The cross passage shall be at an angle of 30 degrees with the direction of flow as shown in **Fig. 7.4**. The cross passage shall have provision for one traffic lane, edge strip of 0.75 m, crash barriers and walkways on either side. In normal conditions, the cross passage shall be barricaded.

7.2.9 *Vertical alignment*

The vertical gradient shall generally be 2.0 percent but in any case shall not be more than 3.0 percent for tunnels of length more than 500 m. In short tunnels, the gradient may be limited to 3 percent. However, in such cases the ventilation system should be designed to take effect of gradient and possible incidence of fire.

7.2.10 *Horizontal alignment*

The horizontal alignment shall be straight as far as practicable. However, the straight stretch shall not be more than 1500 m to avoid the effect of monotony and induction

of an unconscious increase in speed. Similarly, the last few meters of the tunnel shall have gentle curve. The curves, if provided, shall be gentle and meet the minimum radius requirements for design speed of the tunnel. Tunnel alignment at the ends and open/ approach cuts shall merge smoothly with adjoining road in the open air. In case of twin tunnel, the crossing of central median shall be provided at suitable locations at approaches of both tunnel tubes so as to allow emergency services gain immediate access to either tube and also to send back diverted traffic to proper traffic lanes.

7.2.11 *Tunnel approach*

Tunnel approach shall have smoothly aligned tunnel walls without any sudden narrowing to avoid a shift from the tunnel wall and a good day/night visibility of the edge lines. Tunnel wall lining shall be of white colour with high luminous reflectance.

7.2.12 *Tunnel portals*

Tunnel portals should, apart from providing protection at entry and exit, convey drivers about the presence of the tunnel reduce the luminance of facing walls and be in harmony with the surrounding environment from aesthetics considerations.

7.3 Geotechnical Investigations

In order to make a realistic geotechnical and geophysical assessment of the ground through which the tunnel is to pass and detailed mapping of surface geology of the tunnel area necessary for the planning and design of alignment and portal locations, shape of tunnel, tunnel supporting systems, minimum distance to be kept between two tunnels, independent geotechnical investigations should be carried in accordance with the provisions of **Section 3 of IRC:SP:91**.

7.4 Structural Design

7.4.1 Assessment of applicable loads shall be based on structural properties of the ground likely to be met during tunneling as arrived from detailed geo-technical investigations.

7.4.2 The design shall cater to the most adverse combination of load conditions including only those loads which have reasonable probability of simultaneous occurring with due consideration for the methodology of construction particularly in case of soft strata and soils. The design shall be checked for loading conditions during the stages of construction, operation and maintenance.

7.4.3 *Tunnels in rock*

Provisions of **IRC:SP:91** shall be followed for the structural design of tunnels passing through rock.

7.4.4 *Tunnels through soft strata and soils*

Structural design of tunnel system passing through soft strata and soils may be carried out by suitable national or international standards, specialist literature and best engineering practices.

7.5 Design of Drainage System

Efficient and effective drainage system shall be provided in the tunnel for the removal of water from rainfall, seepage, tunnel washing operations, vehicle drippings/spillage on firefighting operations.

7.5.1 In order to trap rainwater from hill slopes and prevent it from flowing into the approach cuts and the tunnel, suitable catch water drains shall be provided above the top of sides of the open/approach cuts and above excavated portals.

7.5.2 In the open/approach cuts discontinuous kerbs shall be provided to demarcate the edge of the carriageway. Beyond the kerbs, side drains with adequate waterway shall be provided in the open/approach cuts.

7.5.3 Inside the tunnel, suitable side drains shall be provided behind the kerbs/ crash barriers. Suitable drain pipes going through the kerbs/ crash barriers shall be provided to lead seepage and wash water to the drains. The drains shall be located below the walkways meant for the pedestrians and maintenance personnel. The carriageway shall have suitable camber to facilitate drainage into the side drains. In case of bi-directional tunnel, the camber shall be from the centre outwards and in case of uni-directional tunnel from high speed lane towards low speed lane. The vertical profile shall facilitate self-draining of tunnel. In case this is not feasible, detailed draining system shall be designed by providing sumps and combination of self-draining and pumping arrangements.

7.5.4 The black-topped road surface inside tunnel, generally constructed on rocky subgrade, gets damaged due to seepage water and creates severe problem for surface drainage. Hence the pavement inside the tunnel and in approach cuts shall be of high performance pavement concrete.

7.6 Waterproofing

Waterproofing in the form of tunnel lining such as cast in situ concrete shall be provided for structural protection from surrounding weathering effects as well as operational considerations. To prevent water leaks inside the tunnel, water proof sheet at least 0.8 mm thick with synthetic textile buffer between shotcrete and lining shall be provided.

7.7 Ventilation

7.7.1 Natural ventilation may be sufficient for tunnels of length up to 500 m. However for tunnels of length more than 250 m natural ventilation system should be used only after

thorough evaluation of reliance on natural ventilation especially with reference to effects of meteorological and operating conditions.

7.7.2 Mechanical system of ventilation shall be provided in case of tunnels of length more than 500 m.

7.7.3 Detailed design of ventilation shall be carried out as per **Section 7 of IRC:SP: 91** keeping in view the length, shape, size, tunnel environs and complexion of the likely traffic for which tunnel has been designed.

7.8 Tunnel Illumination

For tunnel illumination/lighting refer **Section 15** of this Manual.

7.9 Tunnel Furnishing

Provisions shall be made for installation of tunnel furnishing such as sign boards, firefighting arrangements, cable trays for telephone and power lines etc. in consultation with relevant local authorities.

7.10 Signages and Carriageway Markings

7.10.1 Variable messages signs inside the tunnel shall be provided for the information of traffic of lane blockage/closure due to incidents related to vehicles/non-vehicles, weather and human hazards etc. or maintenance operations as also to warn of possible hazard ahead due to any abnormal situation. Signage system shall be complemented by providing traffic lights above each lane at the entry portal end and inside. Signages indicating distance travelled, distance/direction to an exit on evacuation route shall be provided inside the tunnel.

7.10.2 Tunnel carriageway markings consisting of a discontinuous line separating the traffic lanes and continuous line separating the lateral traffic lane from the paved shoulder and emergency lay-bye shall have good day/night visibility and conform to **IRC:35**. The markings shall be done by means of self-propelled machine which has a satisfactory cut-off capable of applying broken line automatically.

7.10.2.1 Material

Carriageway marking shall be as specified in IRC (Code of Practice for Road Markings).

7.11 Emergency Facilities

7.11.1 Tunnel emergency facilities to mitigate damage in the event of incidence of fire or any other accident in the tunnel shall be provided in conformity with the standards for installation of emergency facilities according to the classification based on traffic volume and length of tunnel as shown in **Fig. 7.5** and guidelines of emergency facilities for each classification of tunnel vide **Table 7.1** as per details in **Para 7.11.2**.

7.11.2 Types of details of emergency facilities to be provided are categorized as Information and Alarm Equipment, Fire Extinguishing Equipment, Escape and Guidance Facilities and other equipment. Requirements are as under:

i) Information and alarm equipment

a) Emergency Telephone to be used exclusively for dispatching information regarding the occurrence of an accident to the highway authorities by persons involved in or discovering the accident (installed at intervals of 200 m).

Table 7.1 Installation standards of emergency facilities

Emergency Facilities \ Classification			AA	A	B	C	D	Remarks
Information alarm equipment	Emergency telephone		O	O	O	O	O	Omitted in Class D tunnels less than 200 m in Length
	Pushbutton type information equipment		O	O	O	O		
	Fire detector		O	O				Omitted in tunnel without ventilation system
	Emergency alarm equipment	Tunnel entrance information board	O	O	O	O	O	Can be omitted in tunnels less than 200 m in Length
		In-tunnel information board	O	•				To be installed in Class A tunnels 3,000 m or more in length
fire extinguishing	Fire extinguisher		O	O	O	O	O	
	Fire plug		O	O	•			To be installed in Class B tunnels 1,000 m or more in length
Escape and guidance equipment	Guide board	Emergency exit lamps	To be installed in tunnels with evacuation adits					
		Guide board	To be installed in tunnels with evacuation adits					
		Emergency exit direction board	To be installed in tunnels with evacuation adits					
		Guide board	O	O	O			To be installed in tunnels without evacuation adits
	Smoke discharge equipment and Escape passage		• Evacuation adits to be provided in tunnels of around 750 m or more in length. • Smoke discharge equipment to be provided in tunnels of around 1,500 m or more in length. • Evacuation tunnels provide for those Class AA tunnels and Class A tunnels of a length of 3,000 m or more which empoly a two-way traffic system and a longitudinal ventilation system. • Either evacuation adits or smoke discharge to be provided for Class AA					
Other equipment	Hydrant		O	O	•			To be provided in Class B tunnels 1,000 m or more in length. Tunnels equipped with hydrants are to be provided with water supply ports near the entrance.
	Radio communication auxiliary equipment	Coaxial cables	O	•				To be provided in Class A tunnels 3,000 m or more in length.
		Entrance/exit telephone	O	O				
	Radio rebroadcasting equipment	interrupt function provided	O	•				To be provided in Class A tunnels 3,000 m or more in length.
	Cell phone connectivity		O	O	O	O	O	To be provided
	Loudspeaker equipment		To be provided in tunnels equipped with a radio rebroadcasting equipment (with interruption function)					
	Water sprinkler system		O	•				To be provided in Class A tunnels 3,000 m or more in length, and serviced in two way traffic.
	CCTV		O	•				To be provided in Class A tunnels 3,000 m or more in length.
	Lighting equipment for power failure		To be provided in tunnels 200 m or more in length.					
	Emergency Power supply equipment	Independent power plant	To be provided in tunnels 500 m or more in length.					
		Non-failure power supply equipment	To be provided in tunnels 200 m or more in length.					

LEGEND: O- Mandatory •- Use with consideration

b) Push button type information equipment to be pressed by persons involved in or discovering an accident in order to inform the highway authorities etc of the occurrence of the accident (installed at intervals of 50 m).

c) Fire Detectors: detect fires and automatically notify their location to the Highway Authorities etc. (installed at interval of 25 m).

d) Emergency Alarm Equipment: when something goes out of order in the tunnel, drivers running in the access zone as well as in tunnel promptly notified through this alarm equipment. The system includes entrance information boards at tunnel entrances and the in-tunnel information boards in emergency parking areas in the tunnels.

ii) Fire Extinguishing Equipment

a) Fire Extinguishers: installed for initial control of small-scale fires. Portable powder-type fire extinguishers, two per set, are equipped (installed at intervals of 50 m).

b) Fire Plug: hose-reel water plugs are installed for initial control of ordinary fires. Designed even for road users to be able to handle them (installed at intervals of 50 m).

c) Smoke Discharge Equipment: when a fire arises, this device keeps the spread of smoke to a minimum level and also functions to force smoke to be discharged. Usually, ventilation equipment (working in reverse mode) is used as a smoke remover.

iii) Escape and Guidance Facilities

a) Guide board: in an emergency, these direct road users in the tunnel, the distance/ direction to an exit or evacuation route, the current position, and other information.

b) Escape Passage: These are evacuation tunnels and evacuation exits for the road users in the tunnel to a safe place. The former is built for escape, separately from the main tunnel, while the latter connects the main tunnel to an evacuation which runs in parallel with it, or two main tunnels. The evacuation tunnel may have a vertical clearance of 4.5 m. The exit for evacuation shall be shutter type of light weight and non-inflammable materials. Adequate signage for direction of movement and easy opening mechanism shall be provided. Evacuation tunnel shall be used only by the evacuating persons and emergency vehicles.

iv) Other Equipment

a) Hydrant supply water for firefighting activities by fire service crew. The storage capacity of tank is designed to supply water to the following firefighting measures for at least 40 minutes simultaneously. Design allowance shall be 20 percent extra.

- three fire hydrants (with fire hose)
- two sections of sprinkler
- two hydrants.

b) Radio Communication Auxiliary Equipment: used for communication with the fire squads engaged in rescue or fire-fighting activities in the tunnel.

c) Mobile Connectivity: Arrangements for mobile connectivity shall be provided.

d) Radio Rebroadcasting Equipment: This is installed in the tunnel so that radio broadcasting can be made by the authorities to transmit information in an emergency.

e) Loudspeaker Equipment: reliable information is supplied to those who have alighted from their vehicles.

f) Water Sprinkler System: Sprinkle fire particles of water from water spray heads in order to prevent fire from spreading, support fire-fighting activities.

g) Observation Equipment: CCTV with zoom function are installed at intervals of 200 m.

h) Lighting Equipment for Power Failure: maintains minimum lighting required during power failure or a fire.

i) Emergency Power Supply Equipment: used to keep emergency facilities functioning during power failure. There are two kinds, storage cell type and an independent power plant.

7.12 Safety during Construction

7.12.1 It shall be ensured that all applicable rules and regulations relating to the construction of tunnels are duly complied with in strict conformity with the spirit and body of such regulations.

7.12.2 A Project Safety Plan (PSP) relevant to particular site shall be prepared by the Concessionaire and got approved from the competent authority. The PSP shall address all site-specific issues and take all the identified risk elements. During all operations connected with the construction of tunnels, appropriate safety precautions shall be taken through the implementation of the PSP.

7.12.3 An emergency management plan shall be part of the approved Project Safety Plan which shall be well communicated to all working personnel and prominently displayed at site. Emergency Research Measures should be drawn up to take care of various possible contingencies.

7.12.4 Provisions of **Section 6 of IRC:SP:91** shall generally be followed for safety during construction of tunnels.

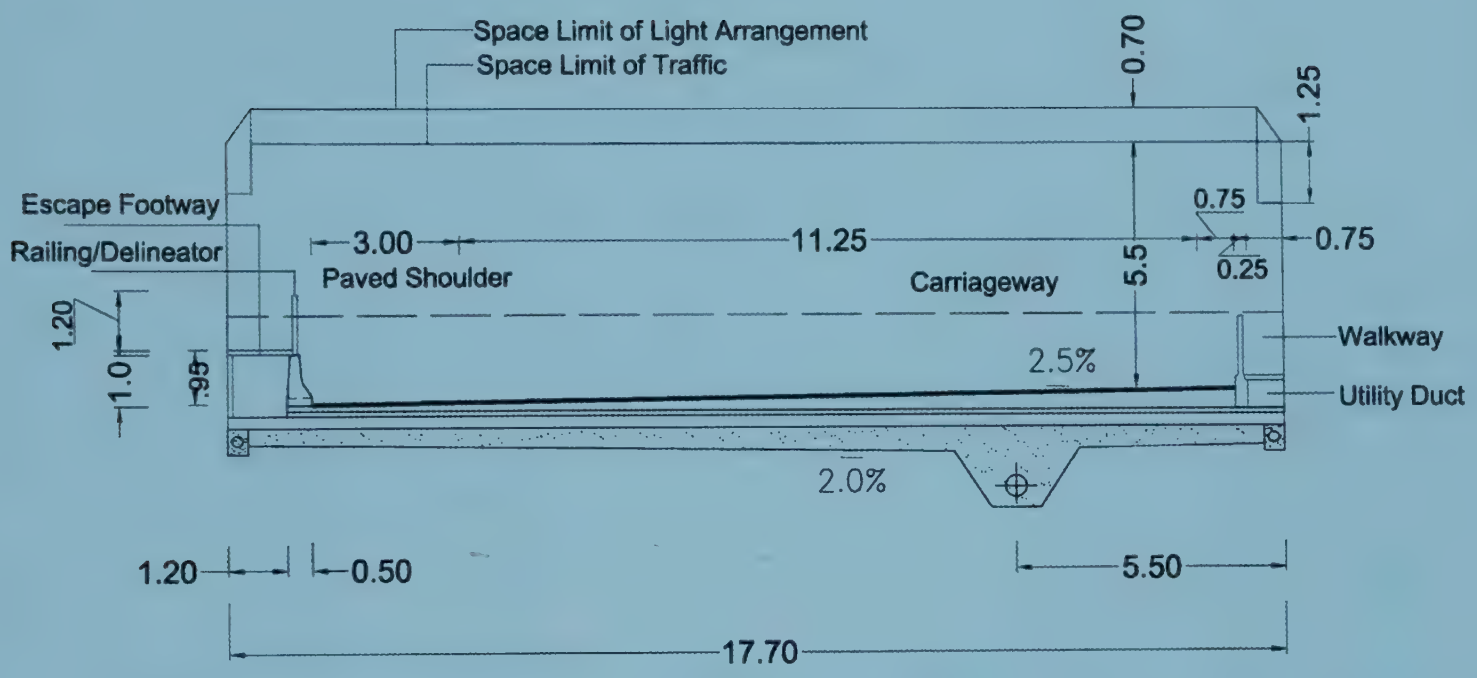


Fig. 7.1 Typical Cross-section of Three Lane Tunnel Cut and Cover Construction

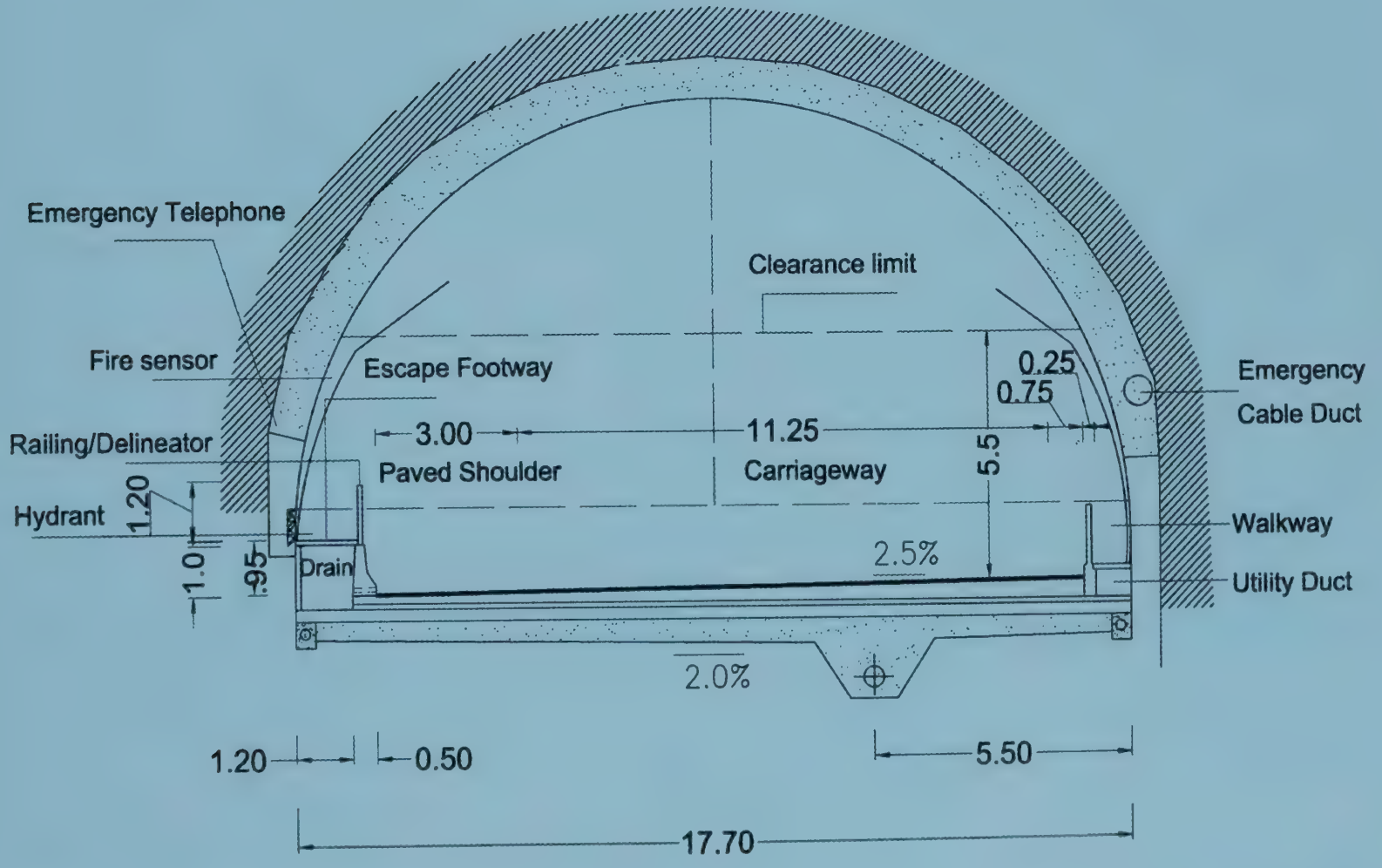


Fig. 7.2 Typical Cross-section of Three Lane Tunnel Mining Type Construction

NOTE *- All Dimensions are in meters*

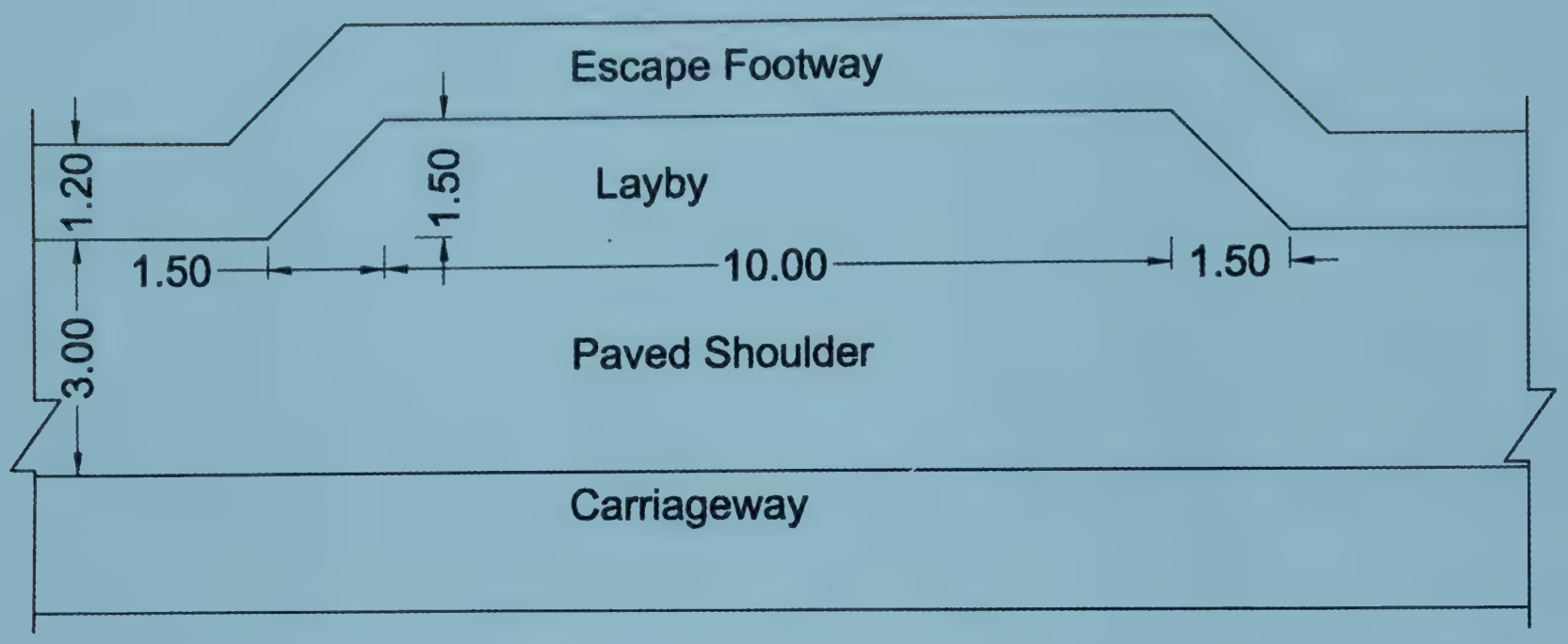
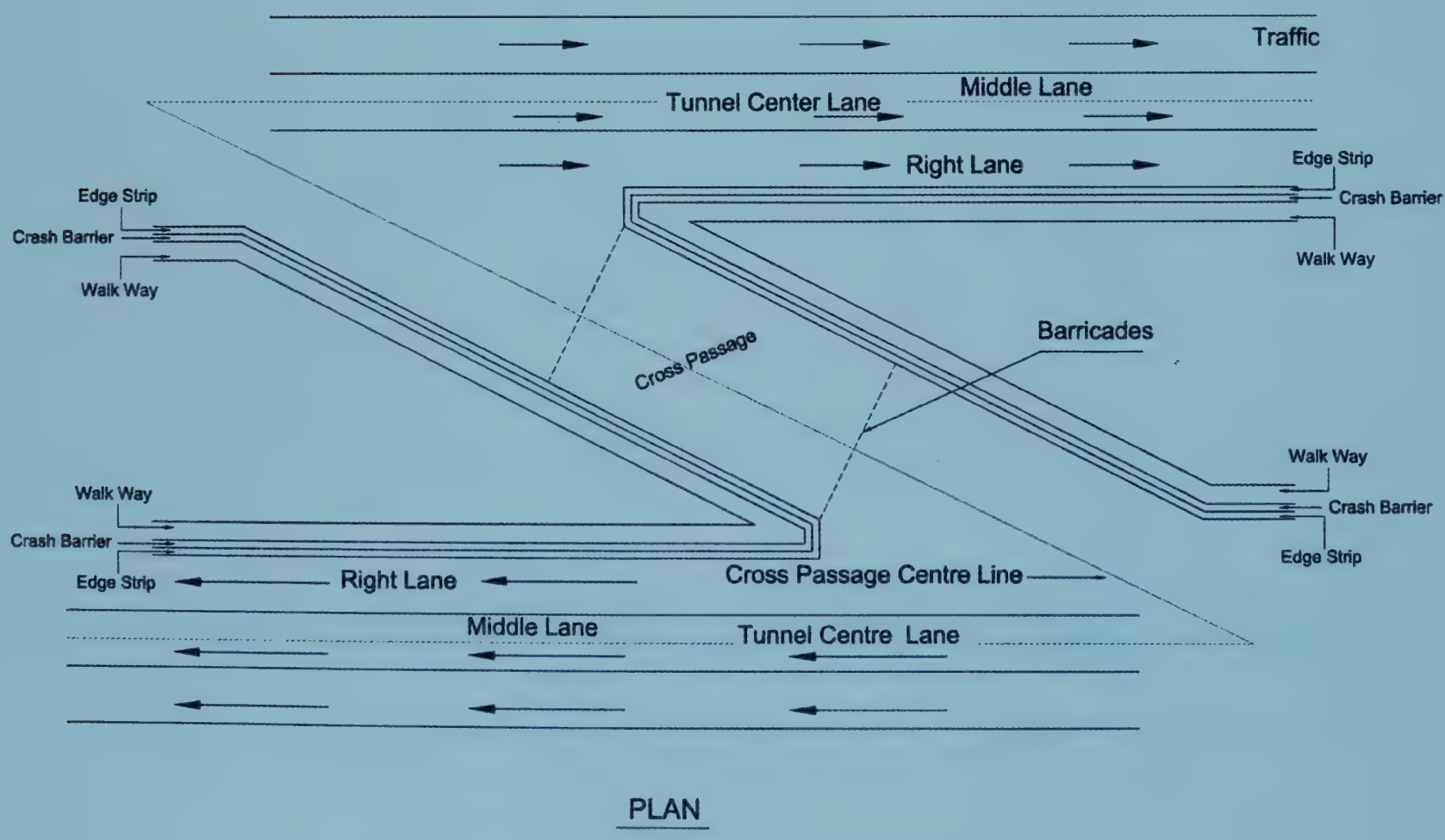


Fig. 7.3 Typical Layby inside Tunnels Length more than 500 m (At 750 m Interval)

NOTE *- All Dimensions are in meters*



PLAN

Fig. 7.4 Tunnel Passage

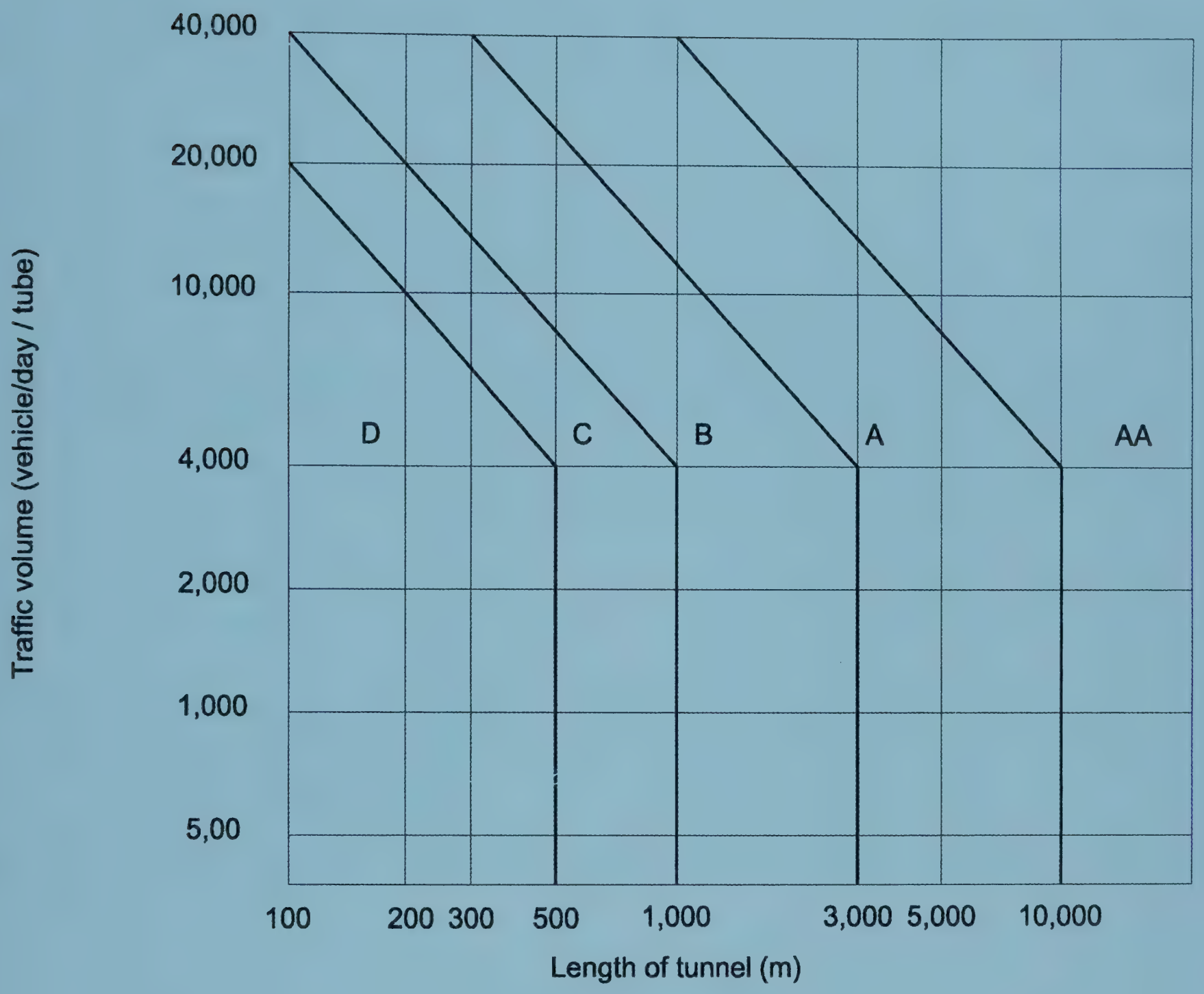


Fig. 7.5 Classification of Tunnels

SECTION 8

MATERIALS

8.1 General

All materials to be used in works shall be in conformity with the requirements laid down for relevant item in MoRTH Specifications. If the Concessionaire proposes to use any material, which is not covered in MoRTH Specifications, it shall conform to IRC or relevant Indian Standards, if there are any, or to the International Standards.

Proprietary products proposed to be used shall be proven by use in comparable international road and bridge projects, and shall be supported with authenticated licensing arrangement with the manufacturer.

SECTION 9

DRAINAGE

9.1 General

9.1.1 The design and construction of surface and subsurface drains for road drainage and drainage for structures shall be carried out in accordance with the requirement of this Section.

9.1.2 For efficient drainage system for the entire Project Expressway including structures, directions contained in **Clause 309** of MoRTH Specifications, **IRC:SP:42, IRC:SP:50 and IRC:SP:90** as relevant shall be followed.

9.1.3 In road sections in cuttings and at underpasses where it may not be possible to drain out the water using gravity flow, vertical drains may be provided and if necessary, arrangement for pumping shall also be made.

9.2 Surface Drainage

9.2.1 The selection of type of roadside drains shall be based on the magnitude and duration of flow. The roadside drains shall be designed on the principles of flow in open channel. Rectangular RCC drain shall be provided. In built up areas the drain shall be covered. The minimum length of drain (lined/ unlined) shall be provided in **Schedule B**.

9.2.2 The road side drains shall not pose any danger to traffic, slopes of cuttings, embankment, pavement or structures.

9.2.3 As far as possible, longitudinal slope shall not be less than 0.2 percent for lined drains and 0.3 percent for unlined drains. Permissible non-erodible flow velocity for corresponding earth surface as mentioned in **Clause 9.4 of IRC:SP:42** shall be kept in view.

9.2.4 The side slopes of the unlined drains shall be as flat as possible and shall not be steeper than 2H: 1V.

9.2.5 The drains shall be provided with Cement Concrete (CC) or Geo-cells filled with concrete lining in the following situations:

i) When due to space constraint, the drains are located near the toe of the embankment or near structures.

ii) Flow velocity is more than 1 m/s in silt and sand; and more than 1.5 m/s in stiff clay.

9.3 Median Drainage

9.3.1 In case of depressed median, longitudinal drain (lined) shall be provided to drain off rain water. The drain should have adequate longitudinal slope to the nearest culvert to drain

off transversely. The bottom of the 'V' shaped cross section shall be lined in 1.0 m length along the slope with 100 mm thick M 20 PCC and the inside concrete surface of V shall be flush with the earthen median slope. In super elevated sections, the longitudinal drain shall be designed to take the discharge from one side carriageway also.

9.4 Drainage Where Embankment Height is more than 3.0 Meters

9.4.1 The height of the embankment shall be measured with respect to the finished road levels. In case of embankment height between 3.0 m to 6.0 m, proper protection of slope by turfing / vegetation or by providing side channel or any other suitable measures shall be adopted. In embankments with height more than 6 m and approaches to bridges, special arrangement for protection of embankment slopes shall be essential in order to ensure that embankment slopes maintain their shape during the monsoon season. In this respect, directions contained in **Clause 7 of IRC:SP:42** may be followed as appropriate for the climatic conditions of the area of the Project Expressway.

9.4.2 Drainage arrangement shall include provision of kerb channel outside the paved shoulder, cement concrete lined chutes along the slopes at designed intervals with energy dissipation basin, side channels at the bottom and protection of the slope by turfing, vegetation and/ or any other suitable type. The drainage system and slope protection shall be kept well maintained at all times.

9.4.3 The chute drains and drains at toe of the embankment shall be of Plain Cement Concrete (M15 grade), over bedding in Cement Concrete M10. The inner sloping face shall be flush with the embankment slope.

9.4.4 Toe drains cross section may be changed to trapezoidal if V shape does not fit as per ground condition.

9.5 Catch Water Drains

9.5.1 Suitable catch water drains shall be provided on the hill slope above cutting to collect and remove surface water run-off from upper reaches. These drains shall be of trapezoidal shape with stone lining pointed with cement sand mortar.

9.5.2 The catch water drains shall be designed to carry the intercepted water to the nearest culvert or natural drainage channel.

9.5.3 It shall be ensured that the catch water drains are provided in stable hill slopes outside the periphery of slide/unstable areas.

9.5.4 Where required, lined chutes shall be provided to lead the discharge to the catch pit of culvert or to a natural drainage channel.

9.6 Sub-Surface Drains

9.6.1 The sub-surface drainage shall be provided

i) For lowering the water table required for drainage of sub-grade;

ii) To intercept or drain out free water in cut slopes; and

iii) For drainage of pervious sub base in situations where it may not be practicable to extend the sub base across the shoulder.

9.6.2 Sub-surface drains shall not be used for surface drainage.

9.6.3 The sub-surface drains shall be:

i) Close jointed perforated pipes or open jointed un-perforated pipes in trenches with backfill material around pipes.

ii) Aggregate drains consisting of free draining material in the trench without any pipe.

9.6.4 Perforated pipes and un-perforated pipes shall meet the requirements of **Clause 309.3** of the MoRTH Specifications.

9.6.5 The internal diameter of the pipe shall not be less than 150 mm.

9.6.6 The sub-surface drains shall be located not less than 0.5 m below the sub-grade.

9.6.7 *Backfill material*

i) Backfill material shall be free draining sand. gravel or crushed stone designed on inverted filter criteria for filtration and permeability, or of an appropriate grading conforming to the requirements of **Table 300.3** of the MoRTH Specifications.

ii) Thickness of backfill material around the pipe shall not be less than 150 mm. The minimum thickness of material above the top of the pipe shall be 300 mm.

9.6.8 Sub-surface drains outside the road pavement shall be sealed at the top to avoid percolation of surface water into these drains.

9.6.9 *Use of geo-textile*

i) The sub-surface drains may be designed using appropriate geo-textile to serve the functions of filtration and separation.

ii) The sub-surface drains can be provided with geo-textile either along the trench or around the pipe or both.

iii) The geo-textile shall satisfy the requirements of **Clause 702** of the MoRTH Specifications.

9.6.10 Trench excavation, laying of pipe, backfilling, and use of geo-synthetics shall conform to the requirements of **Clause 309.3** of the MoRTH Specifications.

9.6.11 The drain outlet shall be a free outlet and shall be provided as per **Clause 309.3** of the MoRTH Specifications.

9.6.12 *Aggregate drains*

i) The trench for aggregate drain shall be of minimum 300 mm width and cut to a depth to expose the granular pavement courses to be drained.

ii) Aggregate for the drain shall be gravel, stone aggregate or slag of grading as per **Table 8 of IRC:SP:42**.

iii) The aggregate drain shall be provided with a geo-textile wrap to act as filtration and separation layer.

9.6.13 Design of subsurface drainage shall be based on a rational basis. Reference may be made to **IRC:SP:42**.

9.7 Internal Drainage of Pavement Structure

i) The sub-base shall be extended across the shoulders for efficient drainage of pavement.

ii) The granular sub-base shall be of proper design and grading to perform satisfactorily as a drainage layer. The drainage layer shall not have material finer than 75 micron size.

iii) A suitable filter of granular material or geo-textile to act as filtration and separation layer shall be incorporated, where necessary, between the subgrade and sub-base to prevent clogging.

9.8 Drainage for structures

9.8.1 *Culverts and bridges*

9.8.1.1 For culverts and bridges, provision of suitable cross slope/camber and down take pipes/ spouts near the kerb, covered with gratings at the inlet points shall be provided at regular interval to facilitate rapid draining of water from the deck without any ponding. The length and location of these drainage spouts should be such that the water is not discharged on any bridge element.

9.8.1.2 The bridges particularly those in high rainfall area shall preferably be built in longitudinal gradient with suitably designed cross drains at abutment locations to facilitate proper drainage.

9.8.2 Grade Separators/Flyovers/Road Over Bridges

9.8.2.1 Effective drainage shall be provided both longitudinally and transversely. The transverse drainage shall be secured by means of suitable camber in the roadway surface. Longitudinal drainage shall be secured by means of scuppers, inlets, or other suitable means of sufficient size and numbers to drain the run-off efficiently.

9.8.2.2 Efficient drainage of the deck structure shall be ensured by providing a suitably designed drainage arrangement consisting of drainage spouts connected to horizontal and vertical pipe system such that the water from the structure does not fall on the road, does not stagnate over the road or at entry and exit points of grade separated structure and is discharged into the draining system of the area. Care must be taken that the pipes are taken down in such a way that they are aesthetically pleasing.

9.8.2.3 Typically, water spouts are provided at the kerbs at the rate of one number per 12 sqm of the surface in level portions and one number per 15 sqm of the surface area on gradients. Water spouts are connected to runner pipe of suitable diameter (minimum 100 mm) on either side of roadway and taken down by down take pipes at pier and abutment locations.

9.8.2.4 Drainage fixtures and downspouts shall be of rigid, corrosion resistant material not less than 100 mm as the least dimension and shall be provided with suitable cleanout fixtures.

9.8.2.5 The arrangement of floor drains shall be such as to prevent the splashing discharge of drainage water against any portion of the structure. Overhanging portions of concrete floors shall be provided with drip moulds.

9.8.2.6 Catch water drains are necessary at the ends of viaduct portion so that water coming from grade separated structure does not over saturate and affect the earthen embankment. Similar catch water drains should be provided at the end of gradient so that water coming from the structure is properly let out to the nearest drain.

9.8.2.7 An integrated drainage plan for the water coming from the deck of structures, local catchment area of the project and all other sources should be prepared so that no water falls on any surface of the structures, or remain standing or flowing over the level roads. All the water is collected through sumps and finally discharged into the local drainage system i.e. storm water drain/pipes etc. either by gravity through connecting drains or by pumping into the existing outgoing drains.

9.8.2.8 The rainwater from the deck of the structures usually does not flow transversely but flows on the high gradient slopes of the road or approaches and is collected in the valley curve portion. As such attention is to be paid to get this large quantity of water drained out fast without accumulating there causing problems for traffic flow resulting in traffic jams. The draining out systems should be designed with greater margins so as to avoid this problem, at least for grade separators, inside the cities or inhabited areas.

9.8.3 *Underpasses and Subways*

Where rain water cannot flow into the drainage system by gravity due to the requirement of depressed road to get minimum head room, necessary provision for drainage by vertical drains and/or pumping shall be made so that there is no disruption of traffic through such location on account of water logging/flooding of underpass or subway.

9.9 Existing Drains, Canals and Minor Waterways

9.9.1 For the existing drains, canals and waterways, to be over passed by the expressway, draining provisions shall be maintained and the effects of prolonged heavy rainfall must be catered for.

9.9.2 Special attention shall be paid to the drainage channels carrying industrial waste and effluent in particular to those draining chloride contaminated effluents which are detrimental to the RCC structures.

9.9.3 Adequate care shall be taken while crossing irrigation canals to prevent contamination of the flow in the canal by spillage from the expressway.

9.10 When expressway runs parallel to existing channels, adequate measures shall be taken in the form of bank protection and channel alignment to avoid water build up or stagnation against the expressway slope endangering the pavement drainage. The drainage channels at the toe of the expressway may have to be adequately protected or reshaped for discharge into these channels. Where the discharge from road drainage is not permitted, separate cross drainage structures are to be provided on both sides of such channels.

9.11 Erosion control Measures

Erosion control measures in accordance with the provisions of the MoRTH Guidelines for Expressways shall be provided. Guidance may be taken from **IRC:56** for treatment of embankment slopes for erosion control.

9.12 Survey, investigation and design report

The Concessionaire shall carry out proper surveys and investigations for detailed design of the drainage system. The proposal for drainage system supported with survey investigation report and detailed design report shall be submitted to the Independent Engineer for review and comments, if any.

9.13 Drainage studies

The survey and investigation and drainage studies shall include:

i) Alignment plan, longitudinal and cross–sections, contour map.

ii) Hydrological data, Drainage area, water shed delineation, direction of flow, location of outfalls, existing surface drains, ground surface condition, rainfall, flood frequency, etc.

iii) Data for hydraulic design of drains.

iv) Geo-technical investigations for sub surface strata, level of water table, seepage flow, etc.

v) Identification of areas requiring sub-surface drainage.

vi) Any other relevant information. Guidance may be taken from **IRC:SP:19, IRC:SP:42, IRC:SP:48 and IRC:SP:50**.

9.14 Design details

The report shall include:

i) Estimation of design discharge.

ii) Design of surface drains.

iii) Design of sub-surface drains.

iv) Drainage arrangement plan along with plan, longitudinal section and cross– section of drains integrated with cross drainage works and a strip chart.

v) Specifications of drains.

vi) Erosion control measures proposed.

vii) Any additional information as required by the Independent Engineer for review of the drainage system.

SECTION 10

TRAFFIC CONTROL DEVICES, ROAD SAFETY DEVICES AND ROAD SIDE FURNITURE

10.1 General

Traffic Control Devices, Road Safety Devices and Road Side Furniture shall comprise of road signs, road markings, object markers, hazard markers, studs, delineators, attenuators, safety barriers, boundary fences, boundary stones, kilometer stones, etc. MoRTH Guidelines for Expressways and **Section 800** of MoRTH Specifications shall be followed for providing these items unless otherwise specified in this Section.

10.2 Road Signs

The road signs on expressways are required to provide adequate information on lane driving, advance information to exit, location of facilities for road users and also for emergency need for vehicles, Road signs shall be provided as per **IRC:67** and **Section 800** of MoRTH Specifications. Clustering and proliferation of road signs shall be avoided for enhancing their effectiveness. The traffic signs on expressways should serve distinct functions as below:

i) Give directions to destinations, or highway routes, or to other Expressway interchanges and toll plazas;

ii) Furnish advance notice of the approach to interchanges or toll plaza;

iii) Direct road users into appropriate lanes in advance of diverging or merging movements;

iv) Identify routes and directions for important destinations on those routes;

v) Show distances to destinations;

vi) Indicate access to general motorist services, rest, scenic, and recreational areas; and

vii) Provide other information of value to the road user such as weather, maintenance works and occurrence of accidents.

10.2.1 *Colour of signs*

The Colour of all types of signs except direction informatory signs shall be followed as per **IRC:67** (Code of Practice for Road Signs). The Colour of the exit destination direction sign shall be selected as per category of the road. In case of facility signs, black symbol shall be displayed within White Square in blue background.

10.2.2 *Format of legends on overhead and shoulder mounted signs*

The legend on all signboards shall be bilingual-regional/local language and English except on those sign boards located at entry/exit points. Entry/Exit shall have inscriptions in regional/ local language, Hindi and English. The font type shall be as per **IRC 67** (Code of Practice for Road Signs).

10.2.3 *Sizes of signs*

The sizes of various types of signs for design speeds of 80-100 km/hr and more than 100 km/ hr shall be as per **IRC:67** (Code of Practice for Road Signs).

10.2.4 *Size of letters*

Size of letters shall be such that these are legible and visible at design speeds. The size of letters for Advance Direction, Flag type direction, reassurance, place identification and Gantry mounted signs for various approach speeds shall be as per **Table 10.1.** The font size of direction sign to be placed on Expressway shall be based on design speed of Expressway, whereas that on cross road, slip road and loops and ramps shall be based design speed for which they are designed. However, the signs on the diverging section of expressway presenting direction sign towards ramp/loop such as exit Gore sign, shall be designed based on design speed of the expressway. For supplementary plates attached with facility signs, regulatory signs or cautionary signs, the letter size shall be 100 mm. The text size of 100-125 mm letter size shall be used in the supplementary plates with some of the regulatory signs depicting information on typical timings like "09:00 am to 08:00 pm" coupled with dates or days as applicable.

Table 10.1 Letter size of information signs (Gantry Mounted)

Design speed (km/hr)	**Flag type direction signs, reassurance signs, place Identification Signs,**		**Gantry Mounted signs**	
1	**2**	**3**	**4**	**5**
	"x" height lower case (mm)	"x" height upper case (mm)	"x" height lower case (mm)	"x" height upper case (mm)
66-80	140	195	210	290
81-100	170	240	250	350
101-120	245	345	330	460
121-150	280	380	380	530

10.2.5 *Sheeting for signs*

All road signs shall be of Prismatic Grade Sheeting corresponding to Class C Sheeting described in **IRC:67** and any of the sheeting type XI as per ASTM D 4956-09 fixed over Aluminum or Aluminum Composite Material. The sheeting for different type of signs can be chosen based on the selection guidance provided in **IRC:67** depending upon the situation encountered by road users in viewing the signs. Class B/Type XI micro prismatic sheeting can be used for delineator posts.

10.2.6 *Signs on curves*

Wherever the Expressway alignment is on a curve, there shall be advance cautionary signs for sharp curves (depending on whether it is on left or right) and chevron signs (rectangular in shape with yellow background and black arrow) at the outer edge of the curve. The size of chevron shall be as per **IRC:67**.

i) The curves with radii up to 1200 m shall be provided with curves warning sign in advance of hazard and single Chevrons on outer edge of curve. Chevron signs shall be always placed on outer edge of the curve and spaced uniformly for the length covering transition length and the straight portion as given in **IRC:67**.

ii) The curves with radii 1200 m to 3000 m with deflection angle more than 20 degree shall be provided with Chevrons on outer edge of curve at 75 m spacing

iii) The curves with radii 1200 m to 3000 m with deflection angle less than 20 degree and other curves up to 5000 m radius shall be provided with forgiving type delineator posts at 40 m spacing on outer edge of curves.

10.2.7 *Prohibitory signs*

Required prohibitory sign shall be placed prohibiting the entry of certain types of vehicles into the Expressway. Other regulatory and cautionary signs, as per requirement, shall also be provided as per **IRC:67** (Code of Practice for Road Signs).

10.2.8 *Overhead signs*

Locations and size of overhead signs shall be specified in **Schedule C** of the Concession Agreement. The following conditions may be considered while deciding about the locations of overhead signs:

i) Traffic volume at or near capacity,

ii) Restricted sight distance,

iii) Built up stretches,

iv) Insufficient space for ground mounted signs,

v) Distances of important places and routes at suitable intervals

vi) Before major intersections with another Expressway or National or State Highway

vii) Approaches to Interchanges

viii) Multi-lane exits

ix) Entry to Toll Plazas

10.2.9 *Siting of signs with respect to carriageway*

It shall be ensured that any sign or any other device erected for traffic control, traffic guidance and/or traffic information shall not obscure any other traffic sign and shall not carry any advertisement. Between two signs, there shall always be more than 0.6 x V meters distance (where V is the 85th percentile speed in kmph). Signs are normally erected on the shoulder side; but for better visibility for drivers, the sign can be installed on median side also.

Signs shall be mounted on gantries, cantilevers, and butterfly or on over bridges with vertical clearances as applicable for vehicular operations.

The sign supports shall be provided on the earthen shoulder and in the central median. Placement of foundation and supporting structures shall be sufficiently away from the paved surface. Overhead gantry and cantilever supports within the clear zone shall be shielded by a safety barrier system.

Overhead guide signs may be, where practicable, mounted on overpass structures above the expressway to minimize the number of potentially hazardous roadside structures. Special designs for the signboard and/or its mounting may be required where an overpass structure is skewed in plan to the line of the Expressway.

For Cantilever mounted signs, the center of the sign is typically located over the carriageway edge line; however the left edge of the sign shall be positioned no further left than the left edge of paved shoulder. On interchange where weaving of traffic take place, lane dedicated gantry signs shall be located over the relevant lanes, where number of arrow marks lane in dedicated signs shall be same as the number of lanes in the carriageway which they are referring to. When number of signs are erected on gantry whether direction information signs or regulatory or warning signs, the outer edges of signs shall not extend beyond the outer edges of paved shoulders on left hand side and hard strip on median side.

The desirable minimum distance over which signs should be seen is the legibility distance of the principal legend size, plus an additional one third of this distance to allow sufficient time for the driver to see the sign prior to reading its text.

10.2.10 *Mounting height and clearance*

All signs for through traffic shall be provided by overhead gantry/cantilever. Kerb mounted signs supported on GI pipes shall be used at entry/exit of the Expressway or at wayside

amenity/toll plaza areas. Overhead signs shall be placed on a structurally sound gantry or cantilever structure made of GI pipes.

Overhead Gantry shall be mounted at 6.0 m height above the highest point on the carriageway and shall be extended over the entire carriageway plus paved shoulder.

Cantilever Gantry shall be mounted at a height of 6.0 m measured from the carriageway of the sign. Typical cantilever mounted structures and portal type for signs are given in **Fig. 10.1A and Fig. 10.1B** respectively.

10.2.11 *Expressway symbol sign*

The expressway symbol sign is shown in **Fig 10.2**.

10.2.12 *Interchange exit numbering*

Interchange numbering shall be attached at the top of gantry mounted advance direction signs for interchange exit. Typical Exit sign will include the Expressway symbol, Expressway number, Exit number or Chainage as shown in **Fig. 10.3A and Fig. 10.3B,** where the font size for symbol/legend and lettering shall be 200mm(lower case height) and 300 mm (upper case height).

10.2.13 *Advance Guide signs*

The Advance Guide sign gives notice well in advance of the exit point of the principal destinations served by the next interchange and the distance to that interchange. Advance Guide sign should be placed at 500 m, 1 km and at 2 km in advance of the exit. Fractions of kilometers or decimals of kilometers should not be used. Where Advance Guide signs are provided for a right exit, map type signs should be used. Advance Guide sign at 2 km and 1 km will have two principal forward destinations destination also as shown in **Fig. 10.1B,** including two principal destinations served by the next interchange and preferably mounted as Gantry sign. The Advance Guide sign at 500 m will have the two principal destinations served by the next interchange as shown in **Fig. 10.4** and the interchange exit numbering as shown in **Fig. 10.3A** shall be attached along all advance guide sign at 500 m and 2 km. The alternate design of board at 500 m and 2 km can be as shown in **Fig. 10.4A** and can be installed in a cantilever gantry.

10.2.14 *Exit direction signs*

In addition to gantry mounted advance exit guide sign, there shall be cantilever map type sign showing the principle destinations served by the next interchange as shown in **Fig. 10.5.**

10.2.15 *Exit Gore signs*

The Exit Gore sign in the gore indicates the exiting point of departure from the main roadway and also at the start of deceleration lane for the place. Consistent application of this sign at each exit is important. The gore shall be defined as the area located

between the main roadway and the ramp just beyond where the ramp branches from the main expressway. Exit gore sign will consists of two principal destinations served by the next interchange as shown in **Fig. 10.6.** The interchange exit numbering as shown in **Fig. 10.3B** shall be attached along with Exit gore shown in **Fig. 10.6.**

10.2.16 *Next Exit supplemental signs*

Where the distance to the next interchange is unusually long, Next Exit supplemental signs shall be installed to inform road users of the next interchange, **Fig. 10.7**.

10.2.17 *End of expressway signs*

End of Expressway sign shall be placed at the end of expressway section. In the case where an interchange is located near the start or end of expressway, the roads leading to express- way are treated with expressway type advance exit signs. The advance exit signs are placed on the non-expressway section of the route as shown in **Fig. 10.8**.

10.2.18 *Post-Interchange Distance signs*

The post-interchange Distance sign shall a gantry mounted sign consist of a three lines sign carrying the names of significant destination points and the distances to those points. The top one line of the sign shall identify the nearest/next important destination to be shown. Second line is second next exit. The third or bottom line shall contain the name and distance to control city (if any) that has National significance for travelers using the route.

10.2.19 *Distance sign*

If space between interchanges permits, as in rural areas, and where undue repetition of messages will not occur. A Route marker sign shall be installed at 150 m beyond the end of the acceleration lane and the after 300 m the distance sign as shown in **Fig. 10.9**. If space between interchanges permit distance sign shall be placed at every 10 km without encroaching on or overlapping the Advance Guide signs necessary for the next interchange.

Exit numbering signs shall be placed in advance of the exit. There should be a minimum of 3 signs marking each exit; an advance guide sign, an exit direction sign and a gore exit sign. Exit number tabs consists of a white message (200 mm text and 400 mm digit height) on a blue background, and shall be attached to advance guide or exit directional sign. Exit gore signs used in exit numbering shall consist of a white message (250 mm text and 300 mm digit height) on a green background.

10.2.20 *Signing by class of interchange*

Full signing of the interchange should also cover all approaches and ramps. Encompassing the requirements given above, direction information sign for Diamond interchange, Trumpet and Cloverleaf interchange (system interchange) are given in respectively in **Fig. 10.10, Fig. 10.11 and Fig. 10.12.**

10.2.21 *Additional Sign requirement specific to Expressway*

Lane Discipline Information Signs

Vehicle Category wise and speed wise lane dedication information signs are to be installed on high-speed corridors preferably as overhead signs (**Fig. 10.12A**). These signs shall be repeated at every 10 km without interfering with the next exit advance direction signs.

Keep Clear Gap or Headway Sign

Considering the higher speed of the vehicles, it is advisable to keep a safe distance from the vehicle in front to reduce accidents by providing gap safety signage system, along with the chevron road marking giving the idea about the required gap. These marking consisting of a series of chevrons, marked on all lanes at 40 m spacing, as indicated in Figure below, shall be installed at regular interval to maintain safe manoeuvering stopping distance. The start of a series of markings should be at least 1.6 km from the end of a previous entry slip road and should terminate at least 3.2 km before the next slip road **Fig. 10.12B**.

The upright sign as shown in Figure 10.12C may also be used with the marking. A minimum of three such signs shall normally be used spaced at about 100 m., 1 km. and 2km.after start of the pattern. A sign with the legend "Check your distance" may also be provided and placed about 300 m before the commencement of the markings, with a sign showing the alternative legend "Keep your distance" placed about 300 m after the termination of these markings.

10.3 Road Markings

The markings shall be such that these are visible under all circumstances at day and night, wet and dry conditions; must have good contrast with the road surface; must be durable; and must not be so thick that these become a hazard in themselves.

All road markings shall conform to **IRC:35** and MoRTH Specifications unless specified herein. The markings shall be applied to demarcate carriageway lane, edge line, travel line, continuity line, stop line, give way lines, diagonal/chevron markings, zebra crossings and at parking areas using a self-propelled machine with satisfactory cut off value capable of applying broken line automatically.

10.3.1 *Material*

The material used shall have proven performance and shall be as specified in **IRC:35** (Code of Practice for Road Markings).

10.3.2 *Longitudinal markings*

The edge line of main carriageway of expressway (on shoulder and median side) shall be raised profile edge lines as given in **IRC:35** (Code of Practice for Road Markings).

For the Project Expressway designed for 120 km per hour, all curves up to 1000 m radii shall be provided with traffic lane line marking meant for curved sections i.e. with shorter interval as per **IRC:35**. The traffic lane line shall be continuous for curves having radii less than 700 m. For the Project Expressway designed for 100 km per hour, all curves up to 700 m radii shall be provided with traffic lane line marking meant for curved sections i.e. with shorter interval as per **IRC:35**. The traffic lane line shall be continuous for curves having radii less than 450 m. Minimum width of longitudinal edge line marking shall be 200 mm.

a) White colour shall be used for carriageway markings except the ones indicating parking restrictions; for the latter, the colour used shall be yellow conforming to **IS colour No. 356 as given in IS:164**;

b) White together with black colour shall be used for kerb and object markings;

c) Yellow and black colour shall be used on hazard locations and for curves having raddi less than 700 m.

10.3.1 *Other road markings*

a) Directional Arrows and Lettering

Lane selection arrows on pavement shall be provided for guiding, warning or regulating traffic to change correct lane for driving. It shall be white colour. Large numerals and letters should be used.

b) Chevron Markings

A series of parallel chevron markings on a pavement zone, surrounded by continuous line, for indicating closed to traffic shall be provided wherever required.

10.3.4 *Length and gap*

Length and gap of traffic lane line marking shall be 3 m and 6 m on straight reaches and 3 m and 3 m on curves and width shall be 200 mm.

10.3.5 *Longitudinal marking to toll booths*

The traffic lane marking running through the expressway shall be continued till the toll booth, in such a way that traffic from each lane of Expressway is guided to discharge uniformly to different toll booths. Toll booth shall be provided with chevron marking and hazard markers. There shall be transverse bar marking to alert the traffic about the approaching toll booth.

10.4 Road delineators

These are roadway indicators, hazard markers and object markers as given in **IRC:79** and shall be provided on either side of carriageway.

10.4.1 All physical objects above the Finished Road Level (FRL) that are falling within 6 m from the carriageway edge line shall be illuminated with Object Hazard Markers (OHM). The objects shall include utility poles, traffic sign posts or parapet or concrete barrier of bridges, culverts, RE wall, start of underpass or flyovers. The Object Hazard Marker shall be either left OHM or right OHM or Two ways Hazard Marker with respect to position of object to the traffic. The object shall be painted with black and yellow stripes using the paint conforming to **IS:164**. Object markers as per **IRC:79** shall also be used.

10.4.2 The kerbs in the medians/traffic islands and concrete crash barrier over bridges and grade separated structures shall be painted with black and white vertical stripes of 500 mm width as shown in **IRC:35**. The painting shall be continuous at and at highly hazardous sections of road where restriction applies as given in **IRC:35** using the paint conforming to **IS:164**.

10.5 Raised Pavement Markers

The raised pavement markers (RPM) shall be provided to improve the visibility in night-time and wet-weather conditions. These shall be prismatic retro-reflective type two way markers conforming to ASTM D 4280 and provided as per **Table 10.2**. RPM shall be provided on curves and approaches to major bridges, flyovers and interchanges. The RPM on shoulder edge line shall be Red in colour and that on median edge line shall be Yellow colour. RPM shall be provided for traffic lane for all curves less than 1200 m radii and shall be white in colour. The RPM on traffic lane line shall be placed at the centre of gap of lane line marking.

Table 10.2 Warrants for RPM

<table>
<tr><th>Sr. No.</th><th colspan="2">Description of Section</th><th>Length</th><th>Spacing</th><th>Location & Colour</th></tr>
<tr><td>1)</td><td rowspan="3">All sections of Expressway</td><td>Curve radii upto 1000 m</td><td rowspan="3">Curve length including transition with 20 m on either side</td><td>9 m</td><td rowspan="4">For shoulder and median Side edge lines. (Red colour on shoulder side and Yellow colour for median side)</td></tr>
<tr><td>2)</td><td>Curve radii 1000 m to 2000 m</td><td>18 m</td></tr>
<tr><td>3)</td><td>Curve radii above 2000m and straight section</td><td>As per IRC 35</td></tr>
<tr><td>4)</td><td>All sections of Expressway on vertical grade</td><td>Length of highway where vertical gradient is 2% and above and its vertical Curves</td><td>Length including vertical grade and curves and adjoining 300 m portion on either side</td><td>18m</td></tr>
</table>

5)	All Major/ Minor Bridges,	Structure	Structure portion and adjoining 180 m on either side	9m	For shoulder and median side edge lines. (Red colour on shoulder side and yellow colour on median side)
6)	ROBs and all structures (Interchange/ Flyover/VUP)	Approaches	Approach length including the length of acceleration/ deceleration length if any and 300 m adjoining on either side	18m	
7)	All entry/exit slip roads/ ramps and its acceleration/ deceleration lanes	Entry/exit slip roads and ramps	Length of both side edge lines of slip roads/ramp+ edge line of acceleration/ deceleration lane	9m	Red colour on edge lines
8)			Chevron/diagonal markings on gorge	6m	Red Colour for Chevrons/ diagonal markings
9)		Continuity line for acceleration/ deceleration lane for entry/ exit of slip	Length of crossable continuity line for lane changing of entry/exit slip roads	8m	Green Colour for crossable continuity line

10.6 Traffic Impact Attenuators

Traffic Impact Attenuators shall be provided for structural columns of large direction signs, illumination lamp posts, at approaching traffic islands of toll plaza and gore area between diverging roadways. It shall take repeated impacts without any additional recovery procedures and with minimal or no repairs. The attenuators modules shall be moulded from HDPE plastic conforming to the general test acceptance criteria requirement of NCHRP 350 Test Level 3 or EN 1317-3. The space requirement to shield a fixed object should be considered while designing and constructing the attenuators. The design, size, number of modules, etc. of attenuators shall be as per International Standards and location specific duly considering the likely impact. Following general criteria for providing crash attenuators shall be adopted:

a) The 85th percentile speed of traffic plying through the traffic lane adjacent to obstruction in diverge area is greater than 70 kmph.

b) At locations where the lane changing maneuvering of vehicles is substantial.

c) Traffic is required to travel in close proximity to the potential obstruction where it is not feasible to install safety barrier in front of it.

d) The obstruction with high value and if damaged by vehicle impact will have serious consequences.

e) The gore areas of all diverging which are one level above ground.

The specific location shall be identified following the criteria given above and the type of crash attenuators based on severity of the situation shall be indicated in **Schedule B** of the Concession Agreement. For avoidance of doubt, crash attenuators shall also be provided at other locations as per safety requirement and shall be deemed to be covered in the scope of work.

The work of providing and fixing traffic impact attenuators shall conform to **Clause 814** of MoRTH Specifications. **Fig. 10.13** shows the area that should be made available for crash attenuators installations.

10.7 Crash Barriers

There are three types of crash barriers viz., rigid (concrete), semi rigid (metal thrie beam type) and flexible (wire rope safety barrier). The specification of various types of crash barriers shall be as per **Section 800** of MoRTH Specifications unless specified in this Section. The metal beam and wire rope safety barrier shall not be installed upon a structure. For a safety barrier upon a structure, it shall be concrete rigid barrier. Wire Rope Safety Barrier shall not be used over major or minor bridges

10.7.1 *Warrants for Safety Barrier*

10.7.1.1 Main Carriageway of Expressway

Crash barriers shall be provided on shoulder side and median side of main carriageway of Expressway.

10.7.1.2 Cross road, slip road, ramps and loops

i) Embankment height more than 3 m or more shall have safety barrier at the edge of formation. The height of embankment for installation for safety barrier shall be measured from the top of finished road level to bottom level of Original Ground Level (OGL) or invert level of ditch.

ii) Safety barrier shall be provided for all curves upto 450 m radii.

iii) Roadside obstacles such as bridge piers, abutments and railing ends, roadside rock mass, culverts, pipes and headwalls, cut slopes, retaining walls, lighting supports, rain water harvesting system, foundation more than 150 m, traffic signs and signal supports, trees and utility poles shall be protected with safety barrier along with end treatment as mentioned at Para 10.7.4.

iv) Concrete barrier shall be provided at where embankment is retained by a retaining structure (concrete) and on valley side of highway in mountainous and steep terrain (concrete).

v) Between main carriageway and footpath in bridges (concrete).

10.7.2 *Placement for Safety Barrier*

i) The slope in front of Safety barrier shall be near to flat gradient so that safety barrier perform best when impacted by a vehicle and the slope of ground in front of barrier shall not be steeper than 10:1.

ii) On embankments, a minimum distance of 1000 mm shall be maintained between the barrier and the start of embankment slope of a hazard to prevent the wheels from dropping over the edge.

iii) Raised kerbs or drains shall not be provided between the traveled way and the barriers. These destabilize the vehicle balance and disturb its equilibrium before it strikes the barrier thus defeating the essential purpose of safety and redirection of the impacting vehicle. When a kerb exists on the edge of road and on close proximity of traffic lane whether on shoulder side or median side, face of barrier shall line with vertical face of kerb.

iv) The wire rope barriers/systems are suitable for either shoulder and/or median side application, provided there is adequate clearance to account for their deflection, as per manufactures system design specification and standards.

v) When a kerb exists on the edge of road and on close proximity of traffic lane whether on shoulder side or median side, face of Concrete barrier shall always be such that vehicle bumper would directly collide with barrier before wheel touches the kerb face

10.7.3 *Design Aspects*

10.7.3.1 Concrete safety barrier

New Jersey type concrete barriers should be used on flush type median, top of RCC/ RE retaining walls abutting the paved/ earthen shoulder and at other locations wherever used. The crash barrier on retaining/RE walls shall conform to the requirements specified for structures in **Section 6** of this Manual. The road side/median concrete barrier may be pre-cast in lengths of up to 6.0 m depending upon the feasibility of transport and lifting arrangements. Concrete grade for the barriers shall not be leaner than M30. The minimum thickness of foundations shall be 25 mm thick cement concrete or hot mix asphalt placed at the base of barrier to provide lateral restraint. Where more than

75 mm thick overlay on the road pavement is anticipated, the foundation step may be increased to 125 mm. However, concrete barrier should have elaborate footing design which is structurally safe unless sufficient earth support is available. **Fig. 10.14** gives typical details of concrete crash barriers. Suggested flare rates depending upon the design speed are given in **Table 10.3**.

Table 10.3 Flare rates of rigid Barriers

Design speed in km per hour	Flare Rates
120	20:1
100	17:1

10.7.3.2 Metal Beam Safety Barrier

The metal beam type safety barrier consists of steel posts and a 3.0 mm thick Thrie beam rail. There shall be a steel spacer block between the post and the beam to prevent the vehicle from snagging on the post, as the snagging can cause the vehicle to spin round. The steel posts and the blocking out spacer shall both be channel section of 75 mm x 150 mm size and 5 mm thick. The posts shall be spaced 2.0 m center to center with reflective tapes placed on the leg of the post and shall be driven using pile/post driving machine. The rail and splices design details for typical Thrie beam are shown in **Fig. 10.15** or the section of Metal Beam Safety barrier shall be with test report from an internationally accredited testing Agency, conforming to **Para 10.6.3.4**. The crash test report shall be from the internationally accredited testing Agency certifying for all the structural element of Metal Beam Safety barrier, post and beam and related connection details.

10.7.3.3 Wire Rope Barrier

Wire rope barrier can be repaired quickly and only damaged posts are to be replaced. High tension 3 rope or 4 rope wire system confirming the requirements of EN 1317-2 for higher containment Level of H2 shall be used. Typical details of wire rope barrier are given in **Fig. 10.16** and wire rope barrier with ropes interwoven are also presented in **Fig. 10.17.** The wire rope barrier shall be the proprietary product of an approved manufacture and test result shall conform to EN 1317 Part 2.

The Wire Rope Safety Barrier shall not be permitted in following situations:

- In the flush type median
- Where a hazard is present within the deflection area of the fence.
- Where total fence length is less than 50 m

- On a horizontal curve of radius 450 m or less.
- On vertical sag curve of radius less than 3 km.
- Where rate of change in setback is steeper than 1 in 10.

10.7.3.4 *Crash barrier acceptance standards*

The barrier shall be capable of restraining a vehicle from:

a) Penetrating, vaulting over or wedging under the installation;

b) Unless otherwise designed, the barrier must also remain intact so that detached elements and debris will not create hazards for vehicle occupants or other traffic;

c) System must be designed and installed so that spearing does not occur,

i) The vehicle/barrier collision should result in smooth redirection of the vehicle at an angle so that the vehicle will not create hazard to trailing or oncoming vehicles;

ii) The collision must not result in excessive damage to the vehicle occupants.

iii) On main line expressway the crash barrier shall comply with test level of containment Levels H2 as per EN 1317-2 or TL-4 in accordance with MASH.

iv) For all other places such as interchange ramps, connection to local roads, protection of bridge piers on median and road side, etc., the crash barrier shall comply with test level of containment Levels H1 or N2 as per EN 1317-2 or TL-3 in accordance with MASH.

10.7.3.5 Shielding of Object Behind Crash Barrier

When Metal beam barrier or wire rope barrier is installed for shielding an object, minimum distance of 1.5 m between barrier and hazard or the minimum value stipulated by manufacture by an impact of a full sized vehicle. In case of metal beam crash barrier, required working width can be achieved by post spacing at 600 mm.

10.7.4 *End Treatment of Safety Barrier*

10.7.4.1 End treatment for steel barrier: If hit, an untreated end of the roadside barrier can be hazardous, because the barrier beam can penetrate the passenger compartment and cause the impact vehicle to stop abruptly. End treatments should, therefore, form an integral part of safety barriers and the end treatment should not spear vault or roll a vehicle for head on or angled impacts. The end treatment on approach side and on departure side shall be as shown in **Fig. 10.18.** The Metal beam to concrete transition shall be carried out by decreasing the post spacing, nesting one rail behind another and

using steel section behind the Metal beam. The transition between metal beam and concrete barrier is detailed in **Fig. 10.19.**

10.7.4.2 Road Boundary Stones (RBS)

Road boundary stones shall be provided at the boundary on both sides of the Right of Way. These shall be spaced at 100 m intervals. The boundary stones shall be of cement concrete as per Type Design given in **IRC:25**. The boundary stones shall be painted with cement primer and enamel paint and marked "RBS" by yellow and black paint along with Authority name chainage.

10.8 Kilometer

The kilometer stones shall be provided at each kilometer on both sides of the Expressway. The design and specification of kilometer stones shall conform to **IRC:8**. The matter to be written on various kilometer stones and the pattern thereof shall be as specified in **IRC:8**. The kilometer stones shall be fixed at the edge of the earthen shoulders.

10.9 Glare reduction

i) Glare reduction devices shall be installed at the following locations for reducing the headlight glare of opposing traffic at night, which may distract from driving tasks:

a) over the crash barriers in the flush type median

b) On bridges and overpass sections, and

c) On horizontal curves with radii upto 4000 m. Antiglare devices (with minimum 300 mm width and 750 mm height) shall be placed at 4.0 to 6.0 m spacing.

ii) Installation of glare reduction devices can be omitted in the sections with the following characteristics:

a) The difference in the elevation of centerline in opposing directions is 2.0 m or greater.

b) Lighting devices are installed continuously, which regulate use of head lights on high beam.

10.10 Design Report

The Concessionaire shall submit the proposals for traffic control devices, road safety devices and road side furniture together with drawings and details to the Independent Engineer for review and comments, if any. The proposals shall include type, location, material specifications, test reports, installation details and the requisite warranties for satisfactory field performance (as applicable).

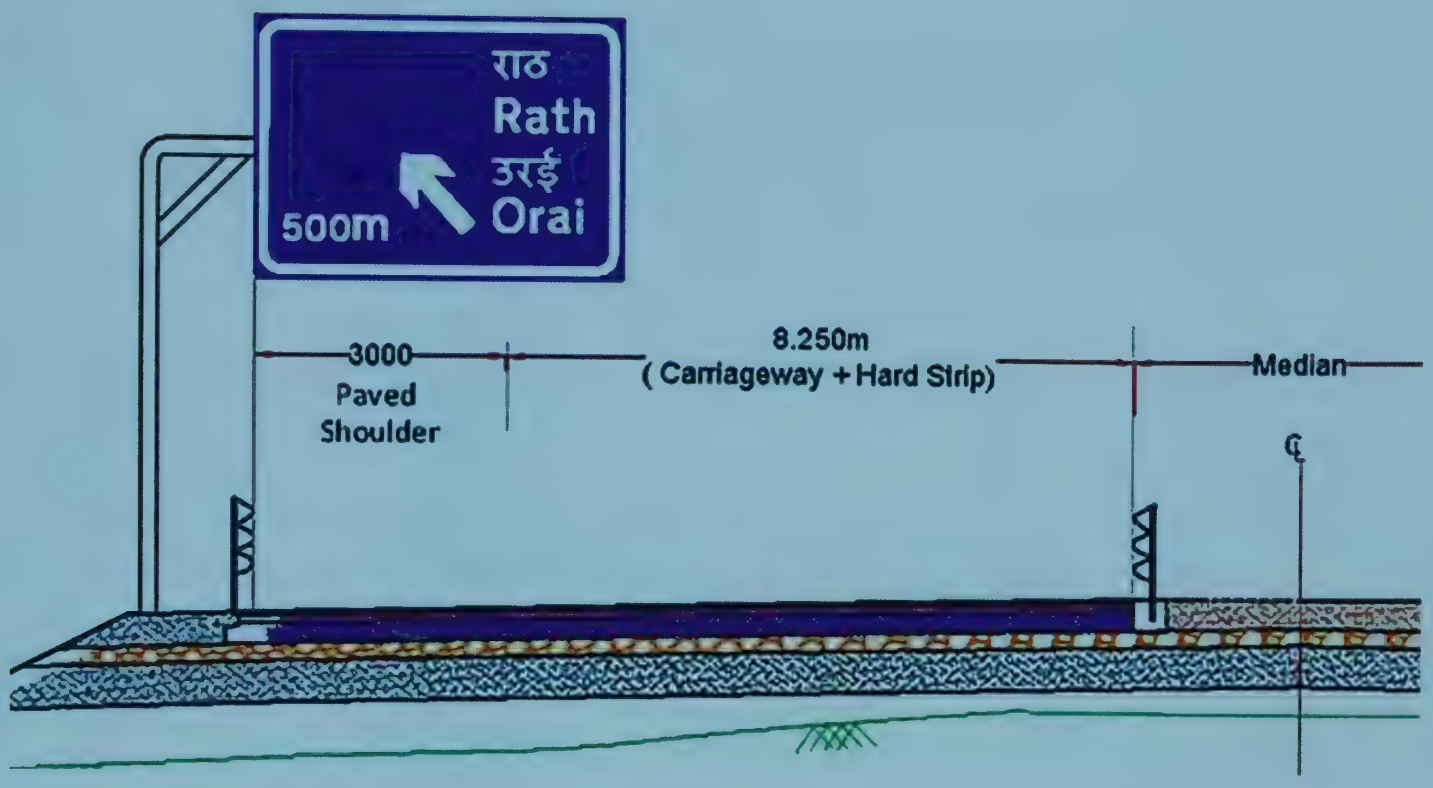
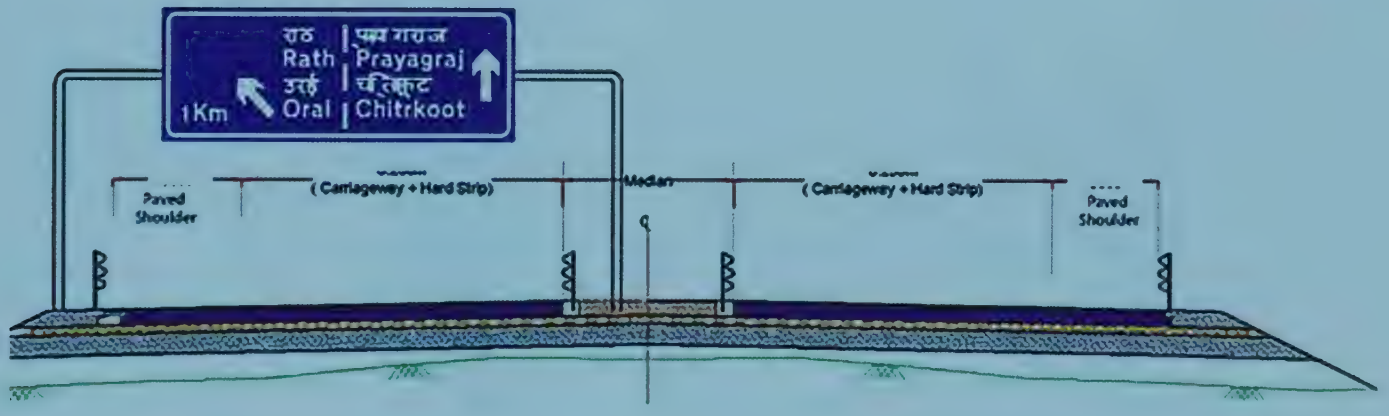


Fig. 10.1A Typical Cantilever Mounted Gantry Structure for Signs



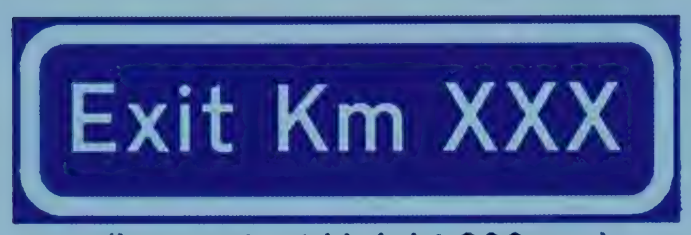
1) Gantry posts shall be placed behind the Metal beam crash barrier.
2) The gantry board shall be always 6.5m above Finished Road Level (FRL).

Fig. 10.1B Typical Portal Mounted Gantry Structure for Signs

Fig. 10.2 Expressway Symbol Sign

(Lower text Height 200mm)

Fig. 10.3A Typical Exit km - Numbering Sign with Symbol



(Lower text Height 200mm)

Fig. 10.3B Typical Exit km - Numbering Sign

Fig. 10.4 Typical Interchange Advance Guide Sign

Fig. 10.4A Typical Interchange Advance Guide Sign

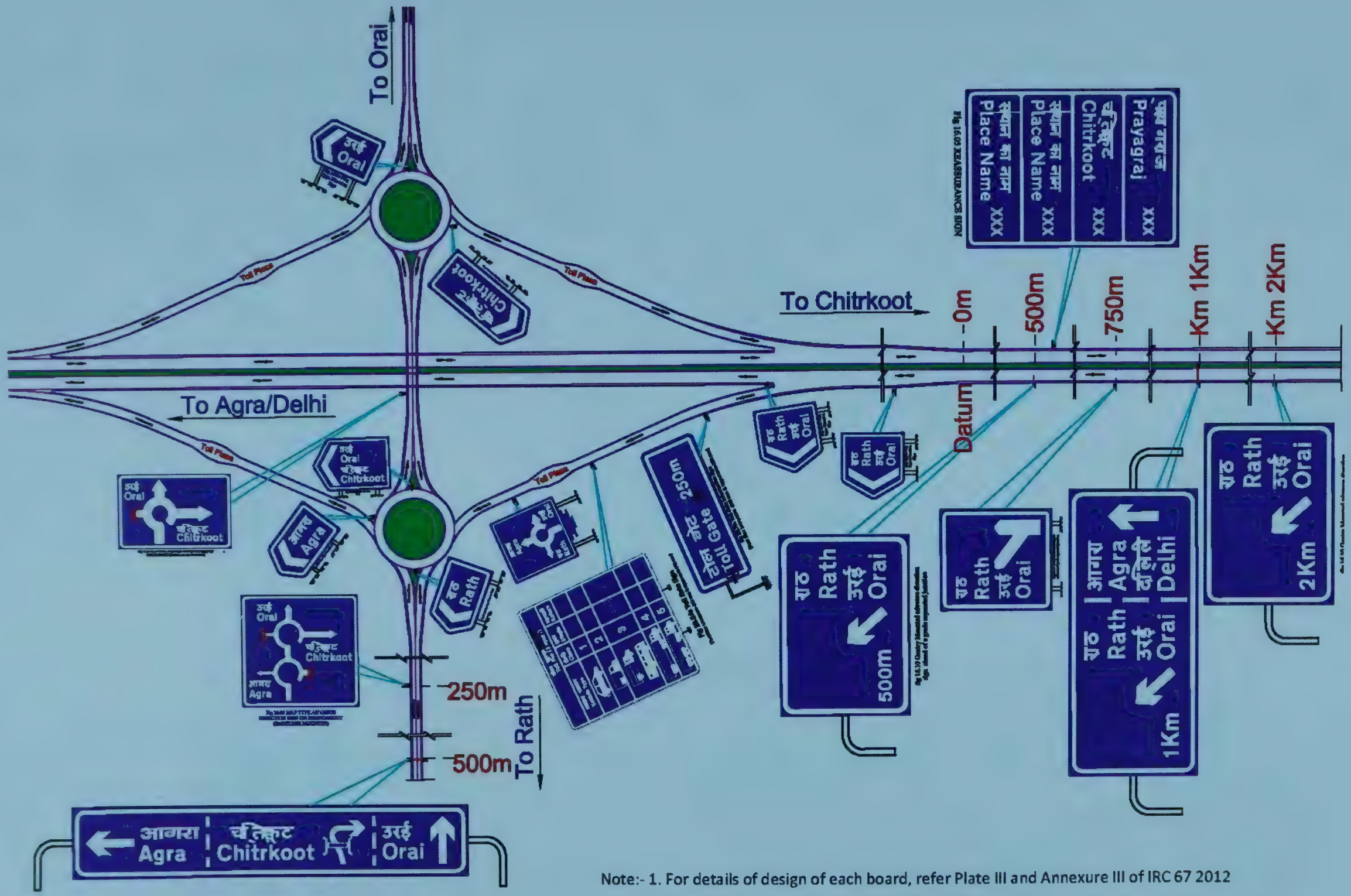
Fig. 10.5 Typical Exit Direction Sign

Fig. 10.6 Typical Exit Gore Sign

Fig. 10.7 Next Supplemental Sign

Fig. 10.8 End of Expressway Sign

Fig. 10.9 Typical Distance Sign (Reassurance Sign)



Note:- 1. For details of design of each board, refer Plate III and Annexure III of IRC 67 2012

2. These are the essential direction information signs from one approach of Expressway and from one approach of cross road.

3. Required Prohibitory, mandatory, regulator, warning, hazard marker signs are to be installed.

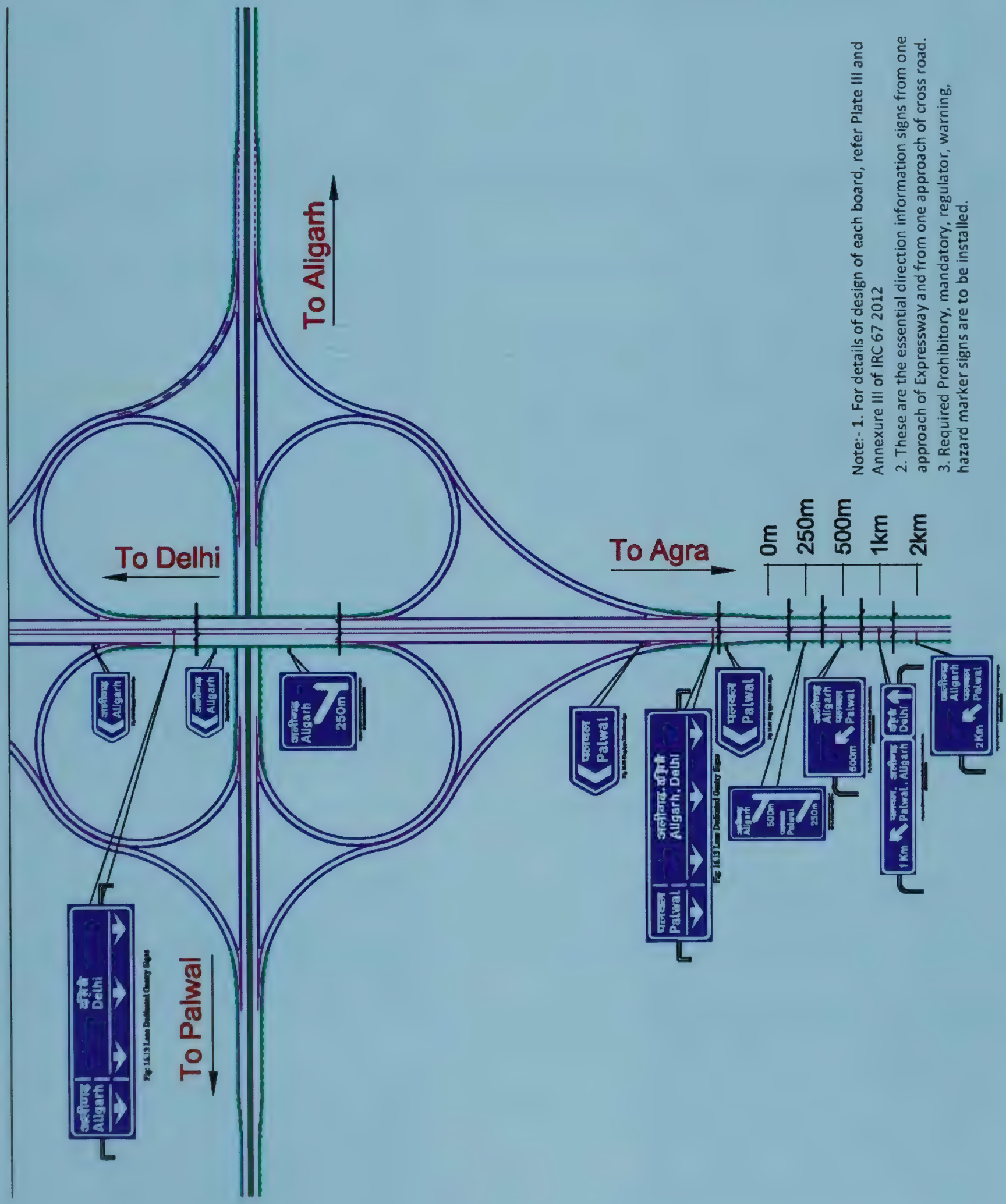
Fig 10.10 Signing Plan for Dumbbell Interchange

Note:- 1. For details of design of each board, refer Plate III and Annexure III of IRC 67 2012

2. These are the essential direction information signs from one approach of Expressway and from one approach of cross road.

3. Required Prohibitory, mandatory, regulator, warning, hazard marker signs are to be installed.

Fig. 10.11 Typical Layout of Trumpet Interchange Sign



Note:- 1. For details of design of each board, refer Plate III and Annexure III of IRC 67 2012

2. These are the essential direction information signs from one approach of Expressway and from one approach of cross road.

3. Required Prohibitory, mandatory, regulator, warning, hazard marker signs are to be installed.

Fig. 10.12 Typical Layout for Full Cloverleaf Interchange Sign

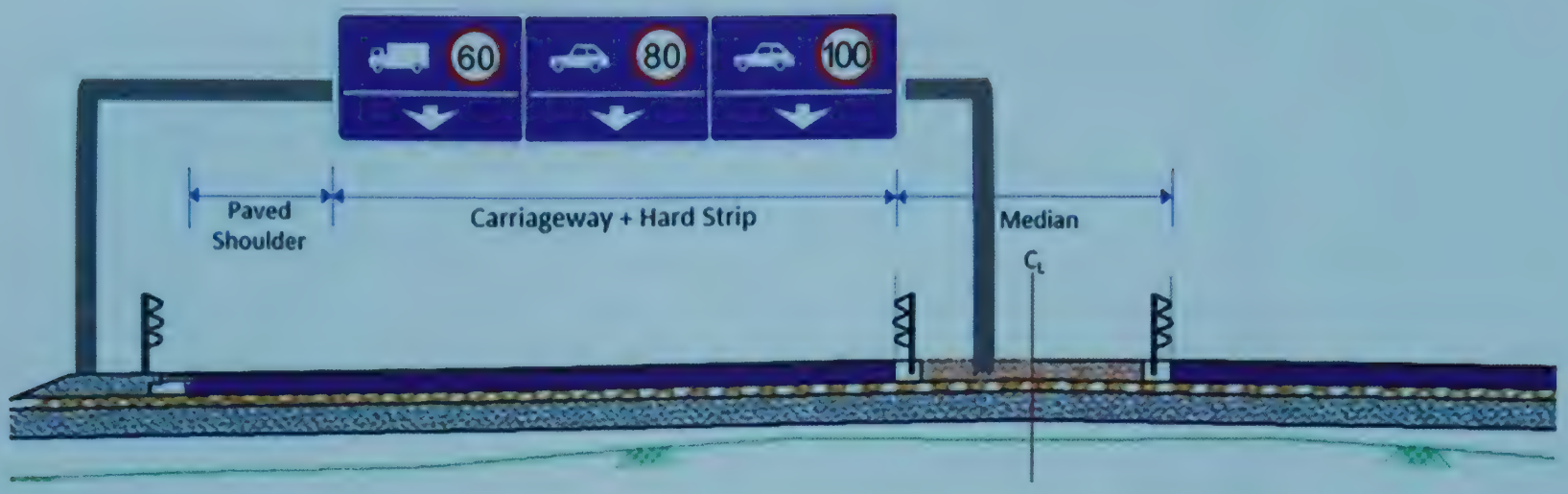
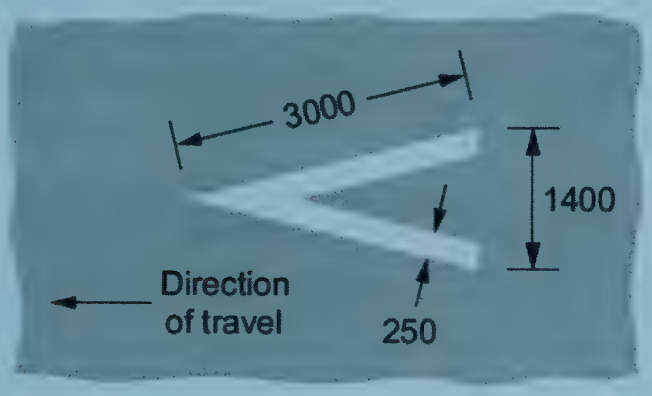


Fig. 10.12A Chevron Marking pattern for Keep Clear Gap Signs



NOTE: Drainage gaps may be provided as appropriate

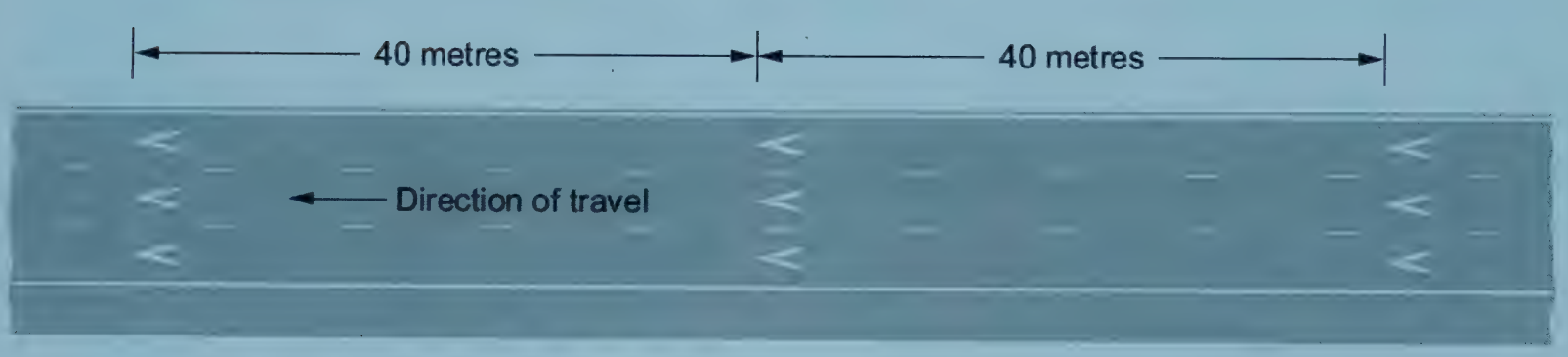
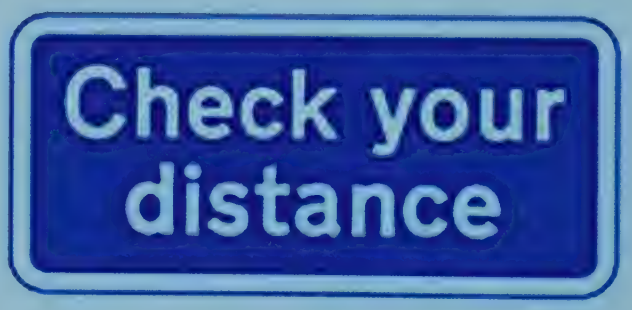


Fig 10.12 B: Chevron Marking pattern for Keep Clear Gap Signs

Fig 10.12C keep Clear Gap



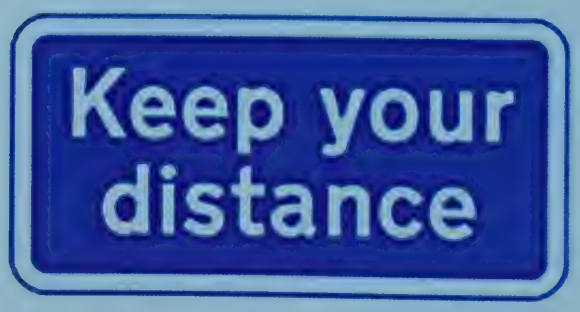


Fig 10.12D

MINIMUM SPACE REQUIRED FOR CRASH ATTENUATORS. i.e. RESERVE AREA (In meter)									
SPEED OF MAIN HIGHWAY (kmph)	MINIMUM SPACE						PREFERRED SPACE		
	RESTRICTED CONDITIONS			UNRESTRICTED CONDITIONS					
	N	L	F	N	L	F	N	L	F
50	2	2.5	0.5	2.5	3.5	1	3.5	5	1.5
80	2	5	0.5	2.5	7.5	1	3.5	10	1.5
100	2	8.5	0.5	2.5	13.5	1	3.5	17	1.5
120	2	11	0.5	2.5	17	1	3.5	2.1	1.5

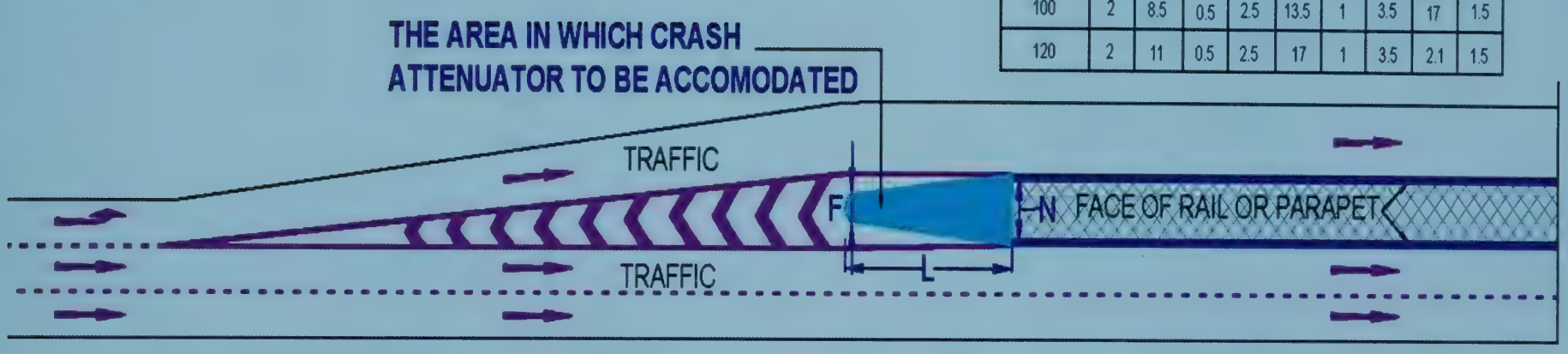
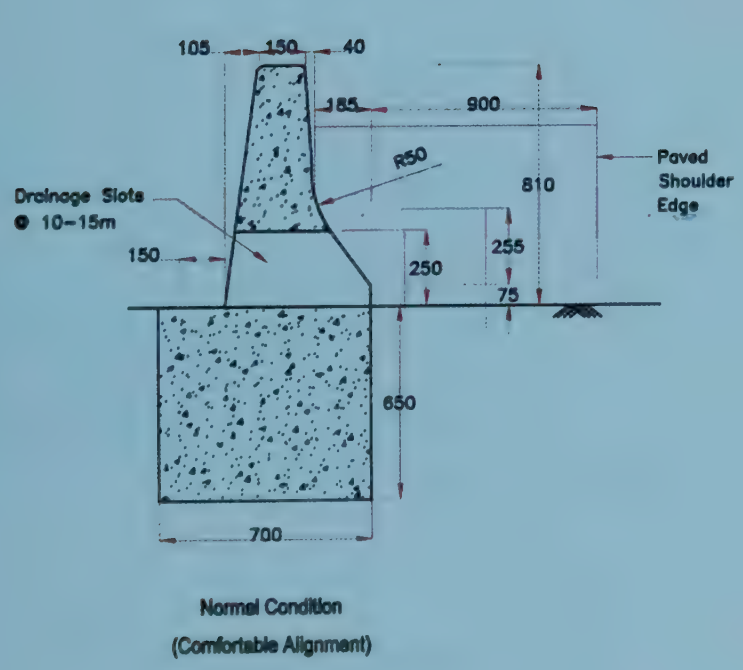


Fig. 10.13 Space Required to Place Crash Attenuators



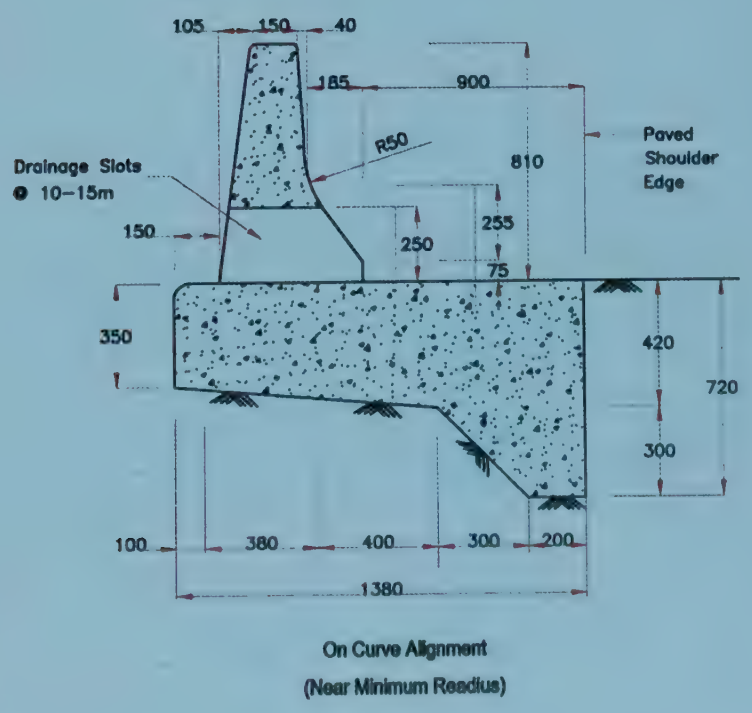
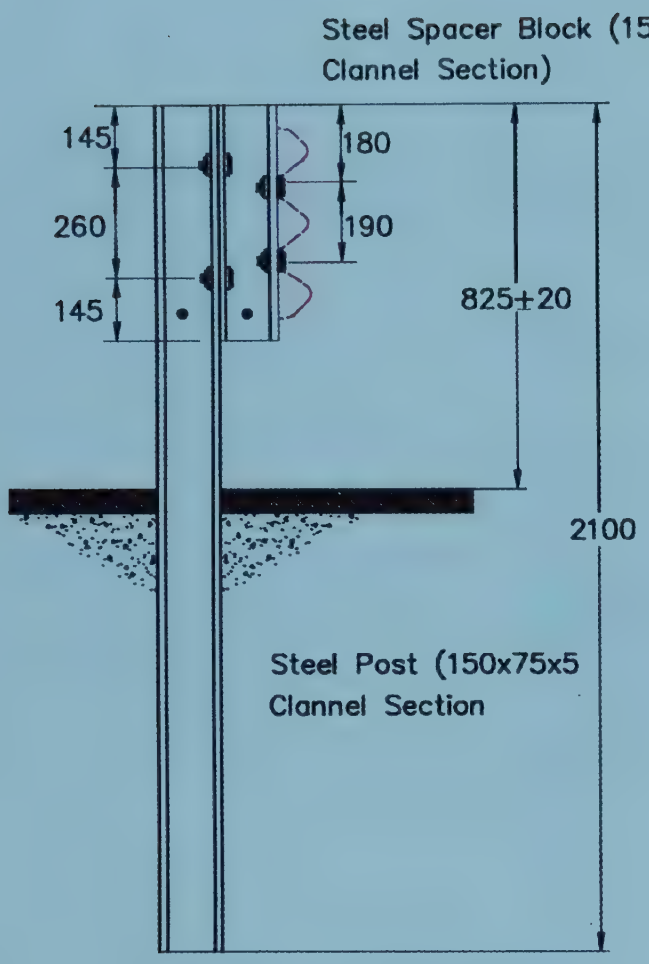
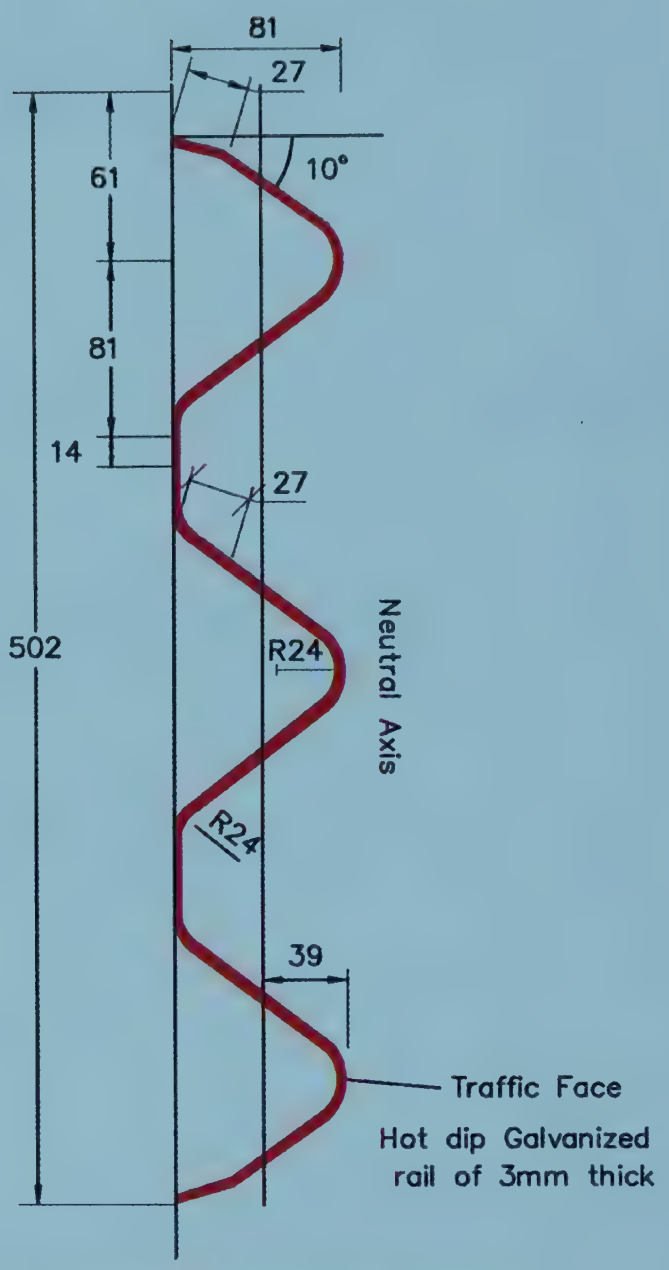


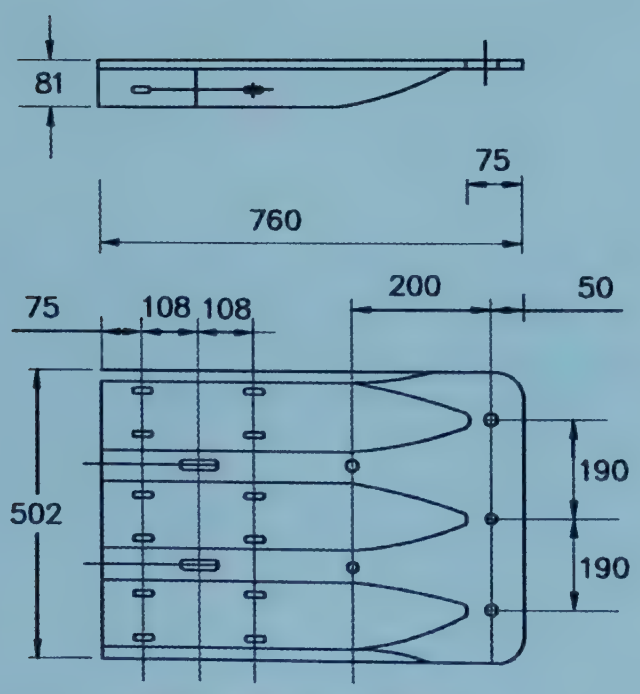
Fig. 10.14 Typical Road Side Concrete Barrier



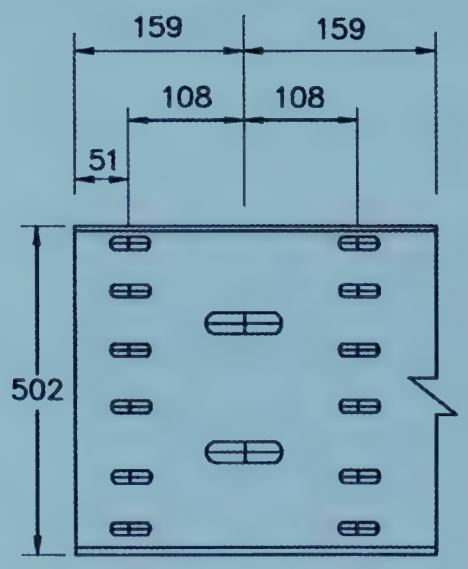
Detail Of Thrie Beam Barrier



Section Through Thrie Beam Rail Element



Thrie Beam Terminal Connector



Rail Splice

NOTE: All Dimensions are in milimeter(mm)

Fig. 10.15 Details of Thrie Beam Structural Elements (Representative)

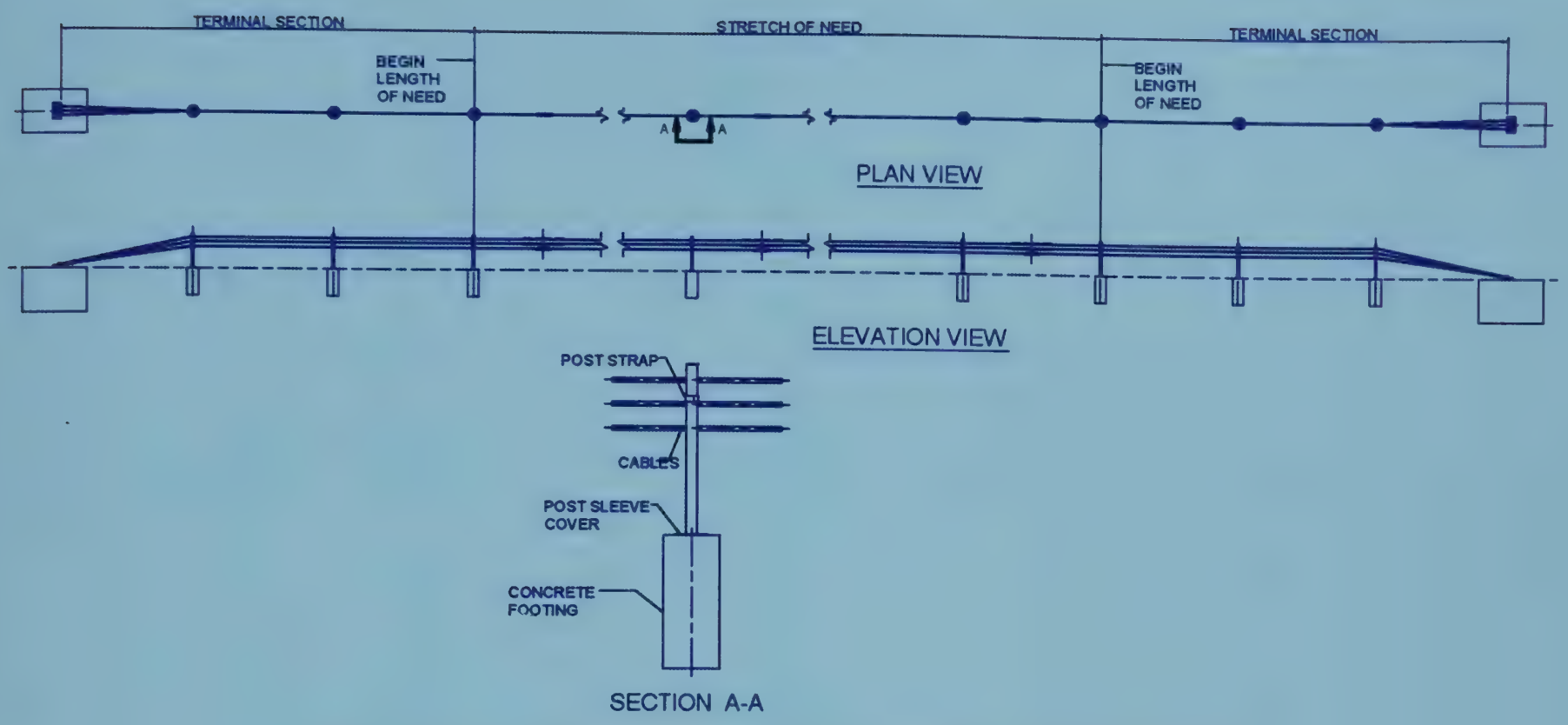


Fig. 10.16 Typical Details of Wire Rope Safety Barrier

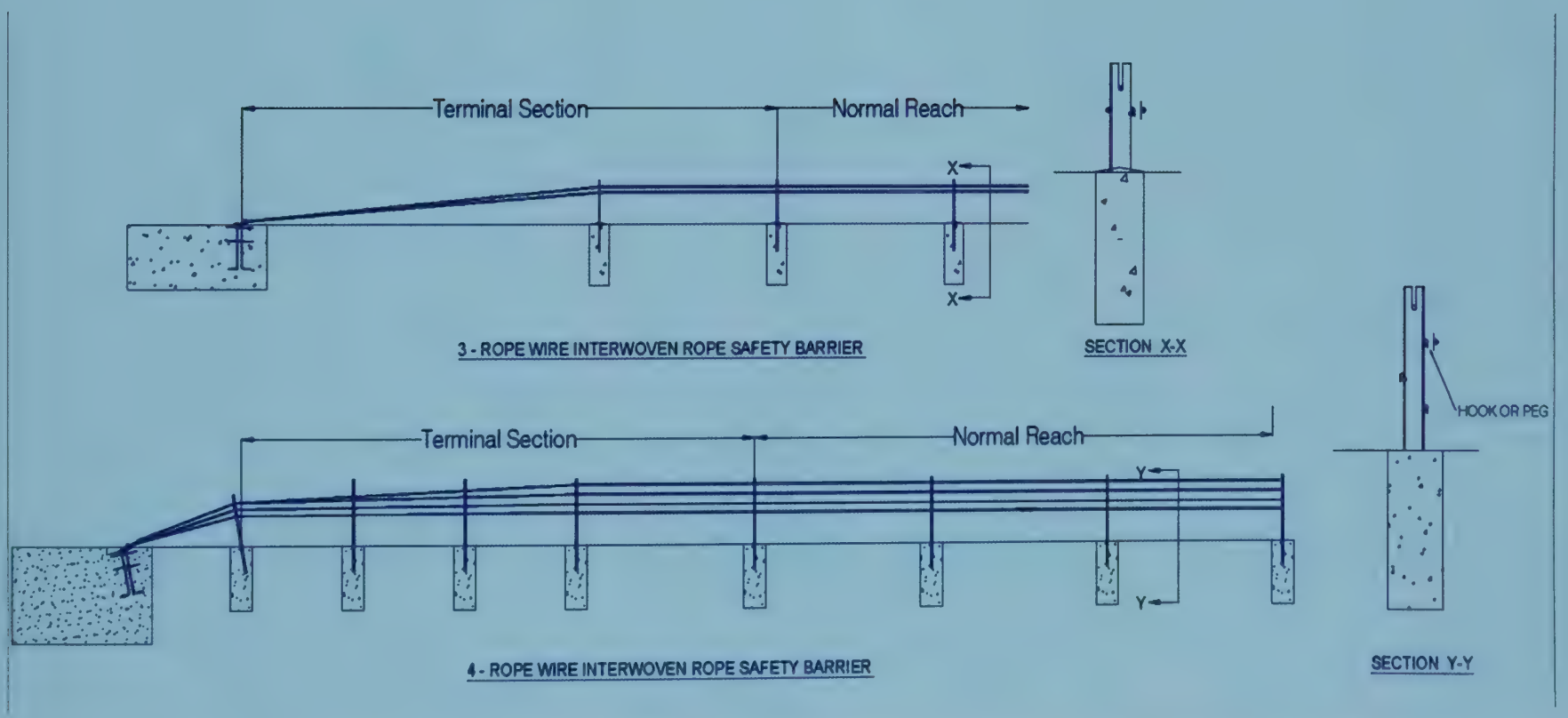


Fig. 10.17 Typical Details of Wire Rope (Interwoven) Safety Barrier

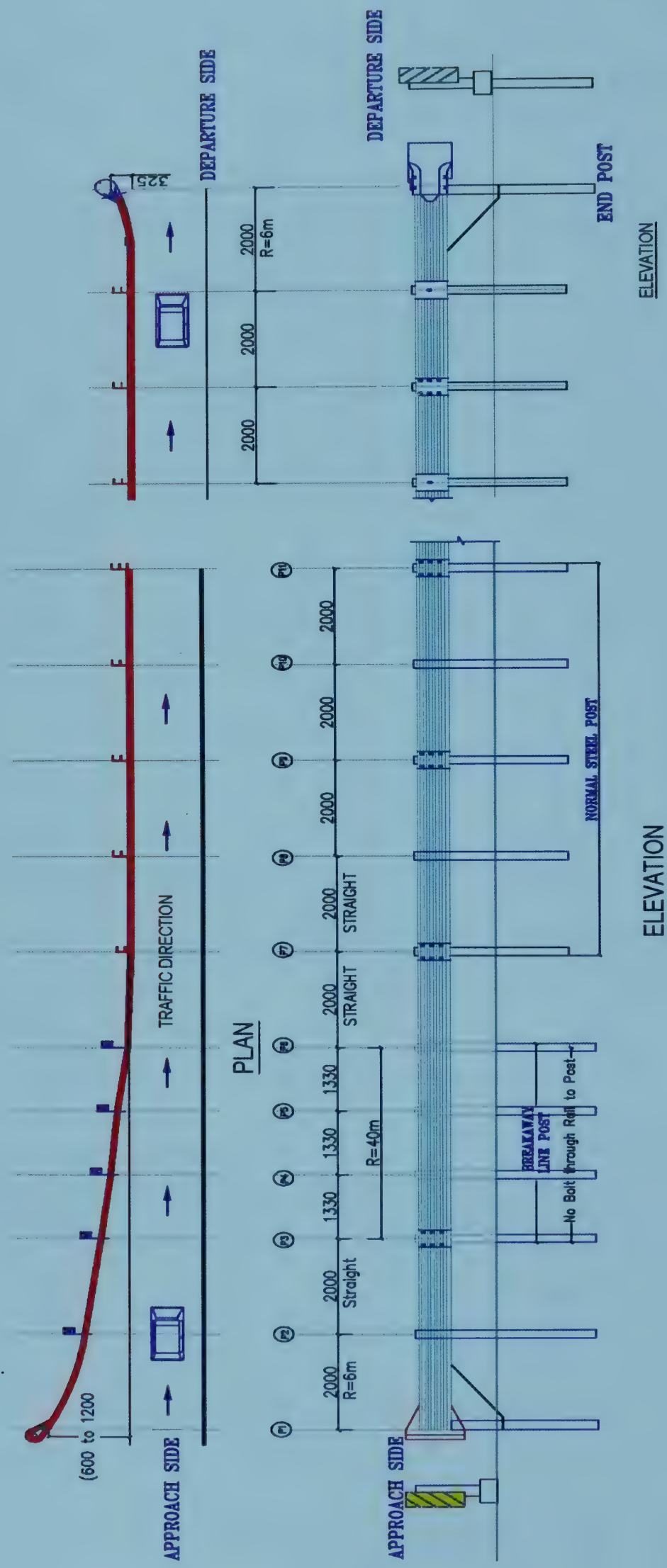


Fig. 10.18 Thrie Beam Ground on Approach & Departure Side

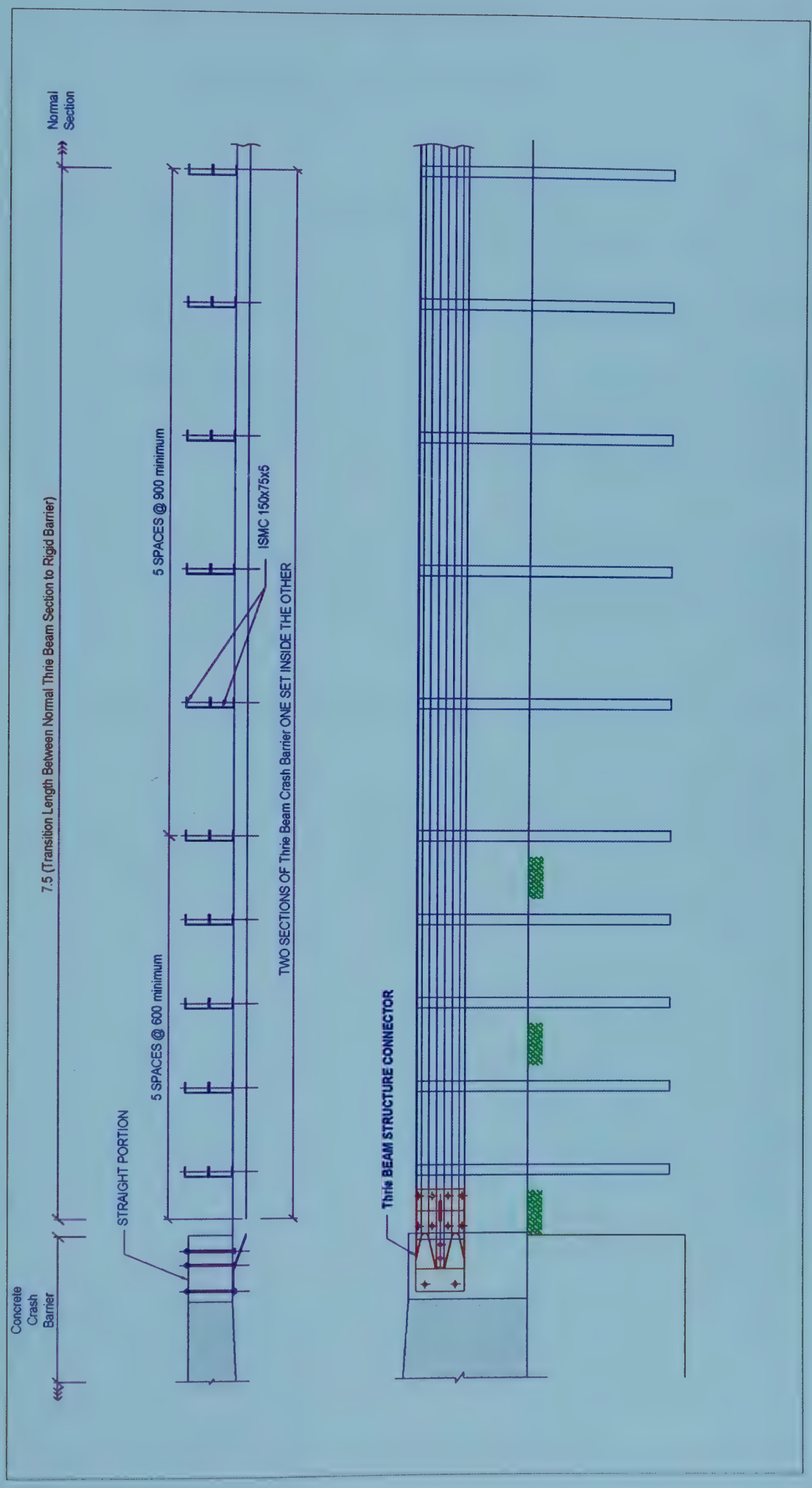

7.5 (Transition Length Between Normal Thrie Beam Section to Rigid Barrier)
Normal Section
5 SPACES @ 900 minimum
ISMC 150x75x5
TWO SECTIONS OF Thrie Beam Crash Barrier ONE SET INSIDE THE OTHER
Concrete Crash Barrier
STRAIGHT PORTION
5 SPACES @ 600 minimum
Thrie BEAM STRUCTURE CONNECTOR

Fig. 10.19 Thrie Beam to Concrete Barrier

SECTION 11

TRAFFIC MANAGEMENT SYSTEMS

11.1 General

Advance Traffic Management Systems (ATMS) shall be provided as per **Clause 816** of MoRTH Specifications for road and bridge works.

ATMS shall have the following sub-systems.

i) Emergency Call Boxes

ii) Mobile Communication System

iii) Variable Message Signs System

iv) Meteorological Data System

v) Automatic Traffic Counter and Vehicle Classification

vi) Video Surveillance System

vii) Video Incident Detection System (VIDS)

Only Locations and minimum quantity of each component of Advanced Traffic Management System shall be as specified in **Schedule B** of the Concession Agreement However, the exact requirement shall be finalized in consultation with the Independent Engineer and any change upto 50% of the the minimum specified quantity, as per site requirement, shall be considered as part of the scope of the work of the Concessionaire without any liability on Authority.

SECTION 12

TOLL PLAZAS

12.1 General

The Concessionaire shall provide the Toll Plaza(s) for collection of toll/fee as per the Concession Agreement. The fee collection system shall be electronic toll collection (ETC) system, unless specified otherwise in **Schedule-C** of the Concession Agreement. The design of the Toll Plaza(s) should be aesthetically pleasing.

12.2 Location of Toll Plaza

The Toll Plaza shall be located at every entry/exit ramp onto/from the Project Expressway.

12.3 Land for Toll Plaza

Adequate land for Toll Plaza shall be acquired to permit the provision of toll lanes for a projected peak hour traffic of 20 years including all other buildings and structures to be accommodated at the Toll Plaza location. Land shall be acquired as per provisions of the Concession Agreement.

12.4 Layout and Design of Toll Plaza (Fig. 12.1 to Fig. 12.7)

12.4.1 *Layout*

a) Toll Plazas shall be designed and constructed for projected peak hour traffic of 20 years as mentioned at **Para 12.3** above.

b) No stage construction of toll lanes shall be allowed. All toll lanes in both directions of traffic shall be ETC/ FAS Tag lanes.

c) For purpose of design of Toll Plaza/ determining number of Toll lanes capacity of individual toll lane (ETC/ FASTag enabled) shall be taken as 900 veh/hour.

12.4.2 *ETC System*

Toll Plazas shall be designed and constructed for projected peak hour traffic of 20 years as mentioned at **Para 12.3** above.

The Concessionaire shall carry out, as per defined technical specifications, installation, testing, commissioning, operations and maintenance of ETC System in all the lanes of Toll Plazas including but not limited to:

i) Installation, integration, testing, commissioning, operations and maintenance of ETC RFID transceiver in all the lanes of Toll Plazas.

ii) Installation, integration, testing, commissioning, operations and maintenance of Medium Speed Weigh in Motion in all the lanes of Toll Plazas and one Static Weigh Bridge in each direction of traffic at the Toll Plazas

iii) Integration, testing, operations and maintenance of ETC RFID transceiver, Medium Speed Weigh in Motion, Static Weigh Bridge and other associated peripheral hardware into a single Toll Management System/Software.

The Concessionaire shall ensure requisite civil work at Toll Plazas is completed prior to installation, integration, testing and commissioning of ETC System. The Concessionaire shall ensure smooth flow of traffic during installation, integration, testing, commissioning of ETC System

12.4.2.1 Scope of Work

a) The Concessionaire shall install, integrate, test, commission, operate and maintain ETC System in all the lanes of the Toll Plazas. The list of equipment to be installed and commissioned for ETC System and their minimum technical specifications have been provided in the Annexure-A.

b) The ETC infrastructure shall be installed, commissioned, operated and maintained for a period of 5 years beyond which it shall be replaced or renewed as the case maybe, by the Concessionaire at cost of the Authority. The same cycle shall be maintained till the end of Concession Period as per the Concession Agreement.

c) The Concessionaire shall set up a system within the ETC System to provide real time data for user fee collection to the Authority as per mutually agreed templates. However, in case of any dispute, the template provided by the Authority shall prevail without recourse to the Dispute Resolution Procedure.

d) The Concessionaire shall set up a system within the ETC System to provide uptime availability data of all ETC lanes in the Toll Plazas to the Authority. The Concessionaire shall design, procure/manufacture, install, test, commission, operate and maintain a monitoring system that meets the concept and functions stated herein and detailed in Annexure-A. However, in case the Concessionaire shows inability to set up a monitoring system, then Authority shall facilitate the set-up of such monitoring system that meets the concept and functions stated herein and detailed in **Annexure-A**. The Authority, if it chooses, can setup a real time monitoring system or software on its own or through its representative. The Concessionaire will have to abide with data sharing of ETC System uptime through this system as well.

12.4.2.2 Service Level

i) The uptime availability of all critical components of ETC lanes shall be 99 percent per lane per month for 90 percent of total lanes in a toll plaza (rounded off to

nearest integer). For the balance 10 percent lanes, uptime availability of all critical components shall be 98 percent per lane per month. The permissible downtime for all critical Equipment shall be 7 hours per lane per month.

ii) The downtime for a toll lane shall be calculated at a cumulative level when any of the below mentioned critical component is non-operational for that specific lane:

- RFID Reader
- Automatic Vehicles Classification Controller and Sensor
- Automatic Barrier with soft cover (full lane width)
- License Plate Image Capture Camera
- Incident Capture Camera
- Any Plaza Level Equipment that results in lane downtime

iii) For all other components of ETC System, the uptime availability shall be 98 percent per lane per month.

iv) Scheduled downtime is defined as a period of time when system will remain unavailable for conducting necessary preventive maintenance, urgent repairs etc. The maximum scheduled downtime for any site shall be 4 hours per lane per month.

v) The formula for calculation of ETC System availability shall be as follows:

System Uptime = [1-{A/(B-C)} *100]

where A = Time for which system is down per month basis scenarios identified in Clause 4B

B = Total time in a month

C = Scheduled downtime basis Clause 4D

vi) The Concessionaire shall maintain adequate inventory to ensure the service levels prescribed in Clause 12.4.2.2 (i) and (iii) are adhered. Spares of critical components of ETC System as identified in Clause 12.4.2.2 (ii) shall be included in the cost of change in Scope of Work Order. There shall be no other provision or payment for additional ETC equipment/hardware from the Authority.

vii) The Concessionaire shall ensure that the ETC Systems are operational as per the service levels defined in Clause 12.4.2.2 (i) and (iii) to facilitate payment of user fee through ETC. In case, a vehicle user with a valid, functional ETC RFID tag with sufficient balance in the linked account is not able to pay user fee through ETC

through any lane owing to malfunctioning of ETC equipment/hardware, the vehicle user shall be permitted to pass without payment of any user fee.

viii) The Concessionaire shall ensure that all ETC transactions shall be uploaded and downloaded as per ICD 2.5 document or latest and PG Guidelines including provision of all certificates like SSL, firewall, domain etc.

ix) The Concessionaire shall ensure that all transaction files of the ETC systems are uploaded as per the service levels defined in the NETC program.

12.4.2.3

A) The Concessionaire shall be provided a list of Acquiring parties by the Authority or a representative of the Authority amongst which the Concessionaire shall select one for the processing of ETC transactions. The list of Acquiring parties may be updated or modified from time to time by the Authority or a representative of Authority and the Concessionaire shall abide by all the terms and conditions of such directives.

B) The Concessionaire shall obtain and maintain at its own cost, adequate insurance cover for any case of accidental damage to ETC Systems. The Concessionaire shall indemnify the Authority against any claims whatsoever on this account.

12.4.3 *Layout*

The layout shall provide for future expansion of toll lanes, if required.

12.4.4 *Width of Toll Lane*

The width of each ETC toll lane shall be 3.5 m, except for manual/smart card lanes, where it shall be 3.2 m, and the lane width for over dimensioned vehicles, where it shall be 4.5 m.

12.4.5 *Traffic islands at the Toll Plaza*

Between each toll lane of the toll plaza, traffic islands are required for traffic distribution. These islands shall be of minimum 35 m length (22.5 m on approach side) and 0.6 m width. Protective barriers of reinforced concrete and traffic impact attenuators shall be placed at the front of each island to prevent out of control approaching vehicles. They shall be painted with reflective chevron markings.

12.4.6 *Number of Lanes at Toll Plaza*

The total number toll lanes shall be such to ensure a service time of not more than 10 seconds per vehicle at peak flow regardless of methodology adopted for fee collection. If at any time, the queue of vehicles in any lane becomes more than 100 meters from the toll booth, then the boom barrier of that lane shall be lifted and the free flow of traffic with no tolling be allowed till the queue comes within 100 m. For this purpose, a yellow

line at a distance of 100 m from Toll booth be marked in each toll lane. This provision shall be prominently displayed/ informed to the users.

Not less than 2 middle toll lanes shall be capable of being used as reversible lanes to meet the demand of tidal flow. One additional lane on either side shall be provided for over dimensioned vehicles.

At entry and exit of the toll booths, the rate of taper for transition length for the carriageway of expressway and ramp carriageway shall be 1:25 and 1:15 respectively.

12.4.7 *Removable Barrier*

Removable type barriers shall be provided for emergency or maintenance area cross over and to accommodate reversible toll lanes.

12.4.8 *Staircase and Over-Head Corridor*

The provision of Staircase and overhead Corridor and vertical clearance shall be provided as specified in the drawings.

12.4.9 *Transition*

A transition of 1 in 10 may be provided from Two-lane/Four lane/ Six lanes section to the widened width at Toll Plaza on either side.

12.4.10 *Drainage*

The toll plaza shall be provided with surface and sub-surface drainage system so that all the storm water is drained off efficiently and no ponding or stagnation of water takes place at any area of the toll plaza.

12.4.11 *Prevention of Overloading*

Toll plaza location shall also be provided with system for checking and preventing overloading of vehicles at toll plaza. WIM should be installed at suitable locations ahead of Toll Plaza. Endeavor shall be made to ensure that vehicles found to be overloaded shall not be allowed to use the Expressway.

12.4.12 *Pavement*

Concrete pavement shall be provided in the Toll Plaza area including tapering zone, from durability and long-time serviceability consideration. The rigid pavement shall be designed as per **IRC:58**.

12.4.13 *Traffic Signs*

A well thought out strategy should be evolved for providing traffic signs and road markings in and around the Toll Plaza in accordance with **IRC:67 and IRC:35**. The

Concessionaire would design the configuration/placement of such signs for toll plaza as are not given in **IRC:67** and furnish to the Independent Engineer for review so as to ensure uniformity of signs in use on all the highways across the country.

Signs should be placed along the Project Expressway, roadway of Toll Plaza to guide and render assistance to the drivers approaching the Toll Plaza. It is necessary to alert the driver about the existence of Toll Plaza two km ahead with repeaters sign 1 km and 500 m ahead. Stop sign shall always be used in combination with certain road markings such as stop line and the word 'STOP' marked on the pavement.

The Toll Plaza sign should be supplemented by the sign advising the users of the notified toll rates (fees) for various types of vehicles and exempted categories of vehicles.

12.4.14 *Road Markings*

The road markings shall be used in accordance with Section-10 of this Manual. The road markings for the Toll Plaza area shall consist of lane markings, diagonals, chevron markings. Single centre line is provided at the centre of carriageway at toll gate to demarcate each service lane. Diagonal markings for central traffic island and chevron markings at side traffic island shall be provided to guide the approaching and separating traffic.

In order to control over speeding of the vehicle approaching toll booth, transverse bar markings, shall be provided.

12.4.15 *Lighting*

The toll plaza shall have lighting system to provide visibility to drivers for the use of facility specially to access the correct service lane and also to the toll collector. Indian Standard 'Code of Practice for Lighting of Public Thoroughfare' **IS:1944** shall be followed. This would be done by interior and exterior lighting as indicated below. Power supply shall be from public power supply system, but standby generating set of the capacity to supply the required power shall be provided at toll plaza.

i) **Exterior Lighting:** Lighting of the Toll Plaza is important for enhancing the night visibility.

The lighting system shall consist of the following major components.

a) High Mast lighting

b) Lighting on both side approaches to the Toll Plaza

c) Canopy lighting of the Toll Plaza complex

ii) **High Mast Lighting:** Normal low light poles are not able to give the required lighting conditions. It is, therefore, necessary to install high mast. A height of 30

m for the mast is considered suitable to have uniform spread of desired level of illumination in the Toll Plaza area for safe movement of vehicles.

iii) **Highway Lighting:** A minimum requirement of illumination on the road surface of 40 Lux shall be ensured. Lighting in minimum 500 m length on either side approaches of toll plaza shall be provided to enhance the safety at night on the Project Expressway and to make the drivers conscious of their approaching the toll gate. These shall be provided on the mild steel welded tubular pole of 10 m height from road surface and with 2 m overhang.

Sodium Vapour lamp or equivalent LED lamp to meet desired lux should be provided for these poles on both sides at 50 m staggered spacing. There should be provision for flashing signals for foggy weather conditions.

12.4.16 *Water Supply*

Adequate water supply shall be provided. For working out water requirement and internal drainage system, reference may be made to IS:1172, IS:5339 and IS: 1742.

12.4.17 *Firefighting System*

Toll Plaza along with Administrative Building, OEM Centre shall have fire/fighting equipment, including smoke detectors and audio-visual alarm system as per Section 4.17.1 of National Building Code, so that the personnel working in the complex and the office and the road users are protected against fire hazards.

12.4.18 *Toll Plaza Complex*

Toll plaza shall have a separate office building so as to provide comfortable office space for manager, cashier and other staff. There shall be separate rooms for TV monitors, meetings, toilets, and for the sale of passes, smart cards, on board units and public interaction. There shall be parking space in the same campus for vehicles for the staff and workers and other vehicles engaged in the operation of the Project Expressway.

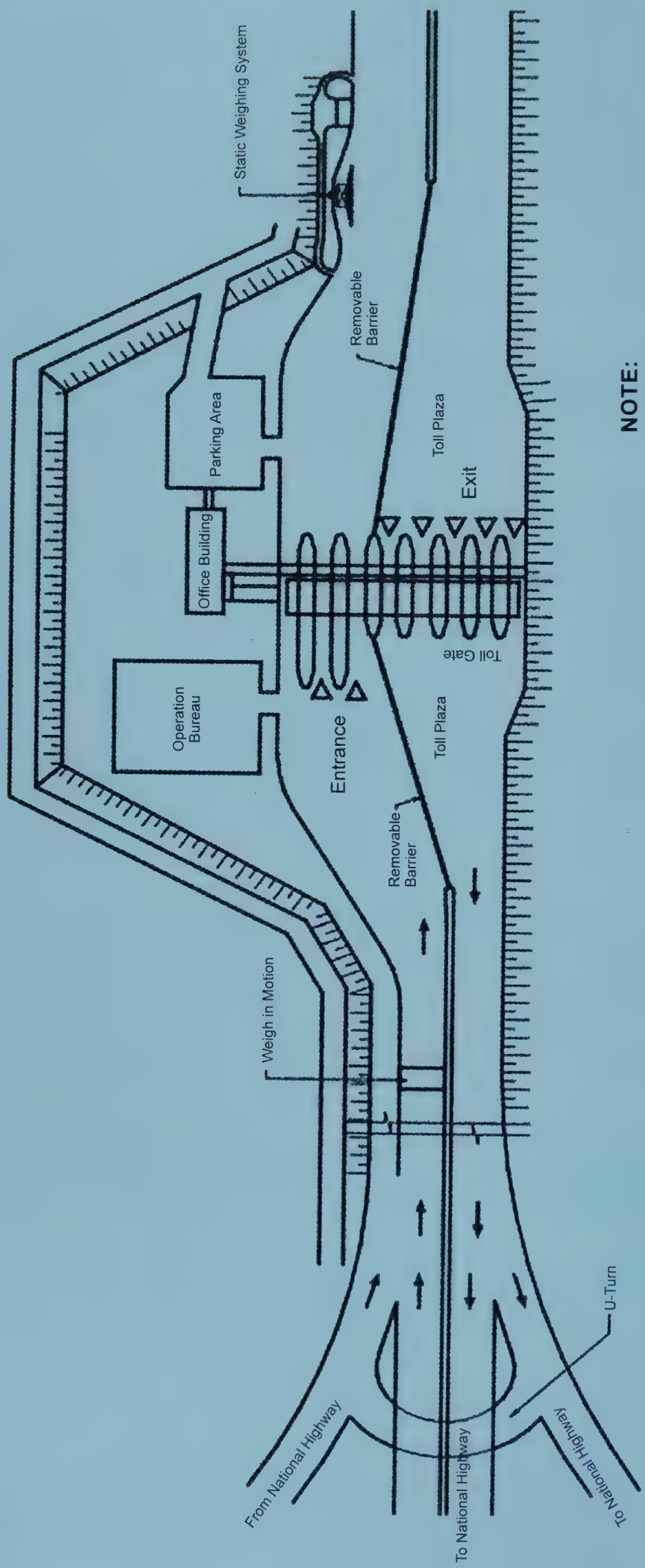
The size of the office complex depends on the minimum requirement of above facilities Provision for future expansion: The office building shall be located taking into consideration of future expansion.

12.4.19 *U-Turn Ramp*

U-turn ramp shall be installed near the toll plaza for vehicles operated by Operations Management personnel for safe operations.

12.5 Report to be submitted

The design and layout of Toll Plaza complex including all facilities shall be submitted to the Independent Engineer for review and comments, if any.



NOTE:

The U - Turn shown in the sketch is an indicative one Location shall be merged with the nearby Underpass Structure.

Fig. 12.1 Schematic Arrangement : Service Facilities at Toll plaza

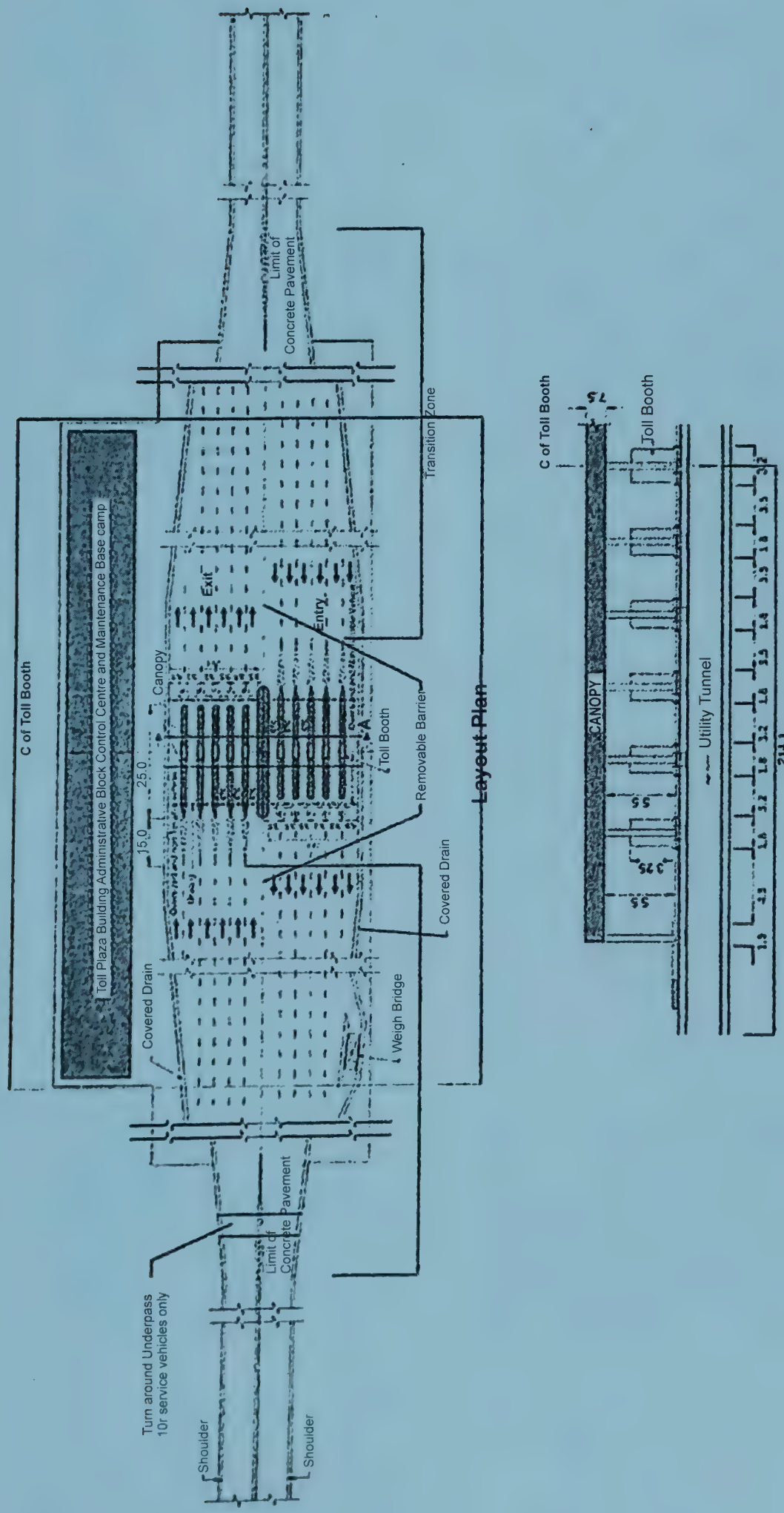


Fig. 12.2 Typical Layout of Toll Plaza

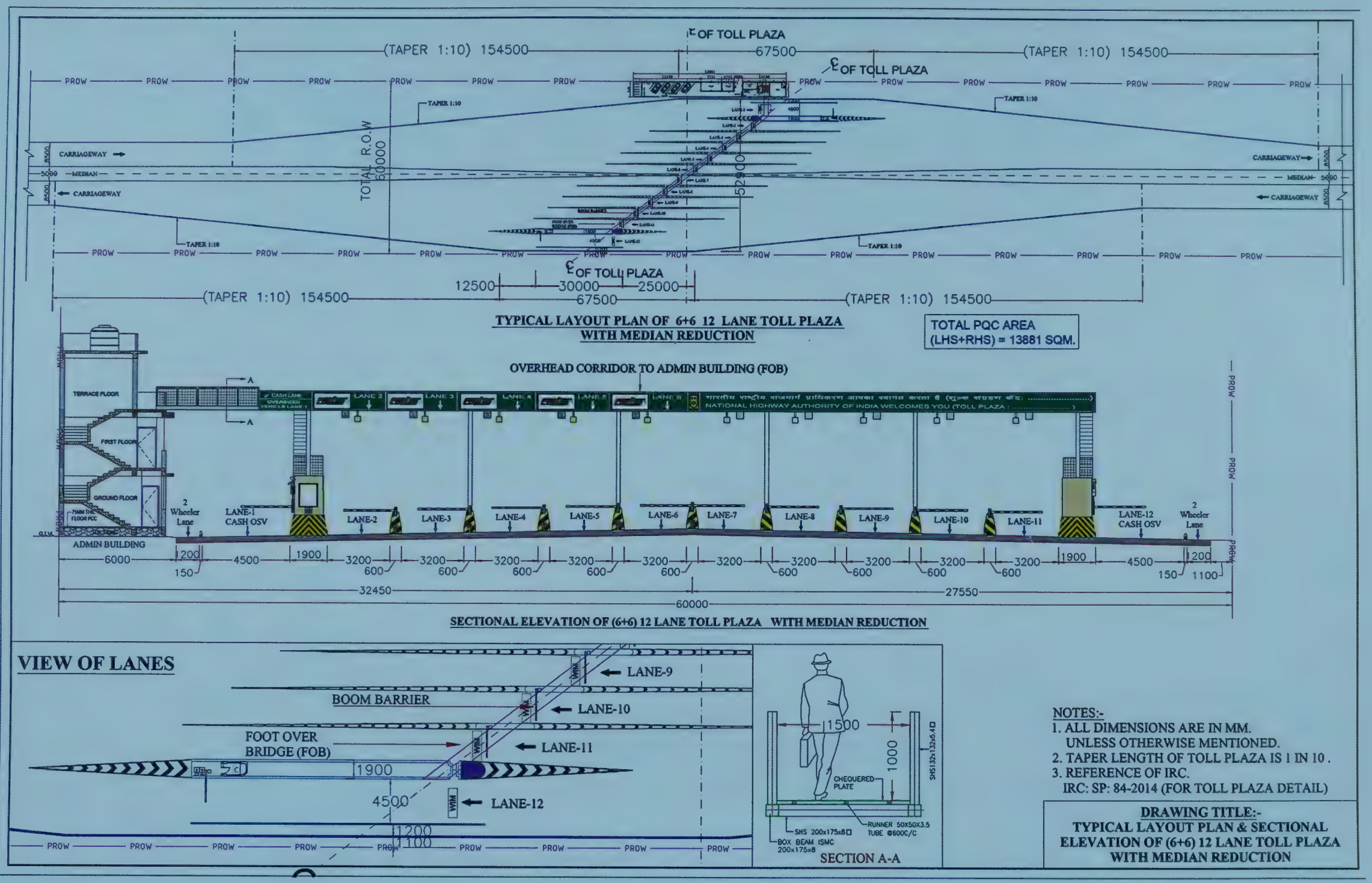


Fig. 12.3 Schematic Layout Plan for Toll plaza

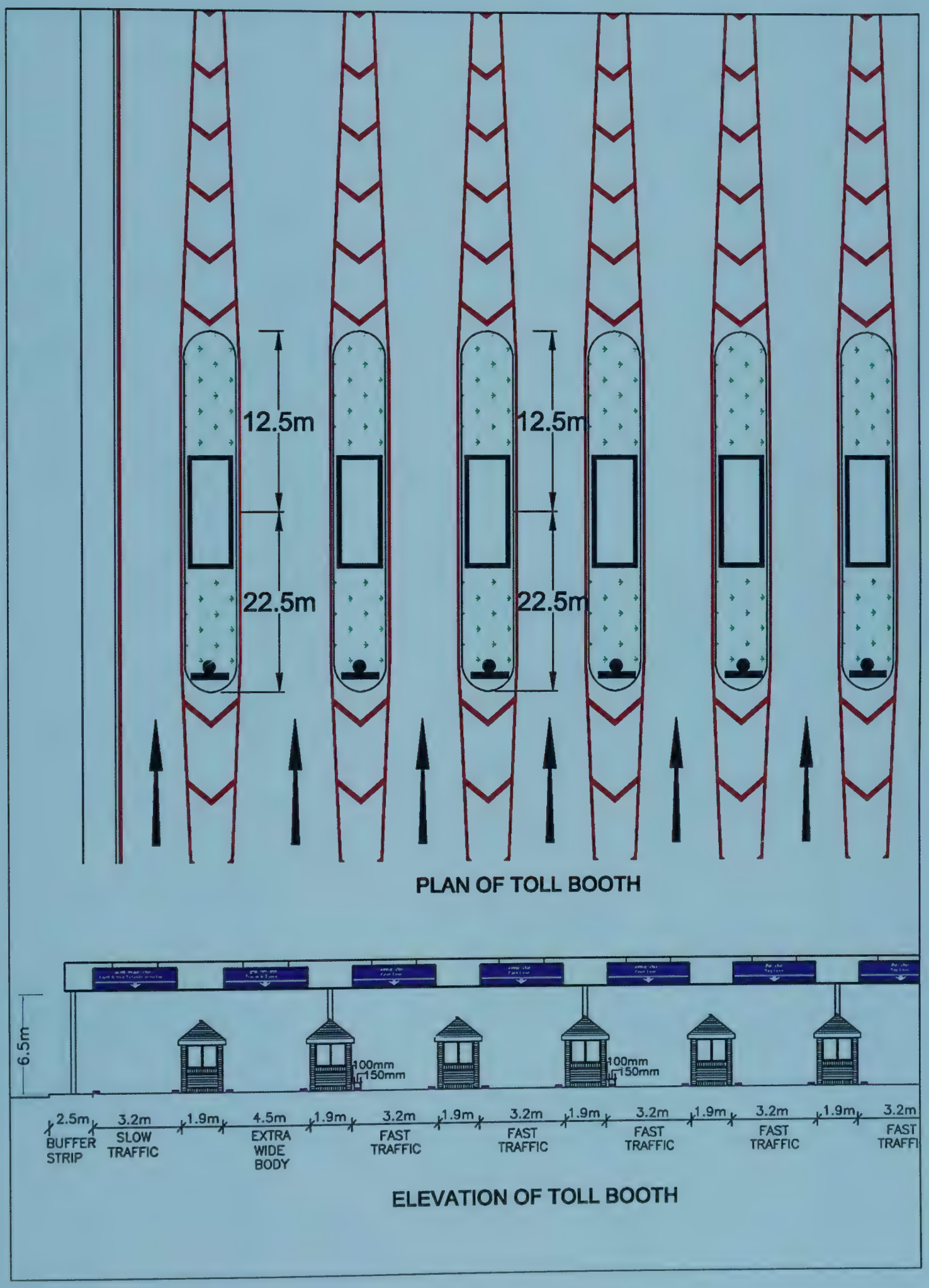


Fig. 12.4 Typical details of traffic island with toll booth

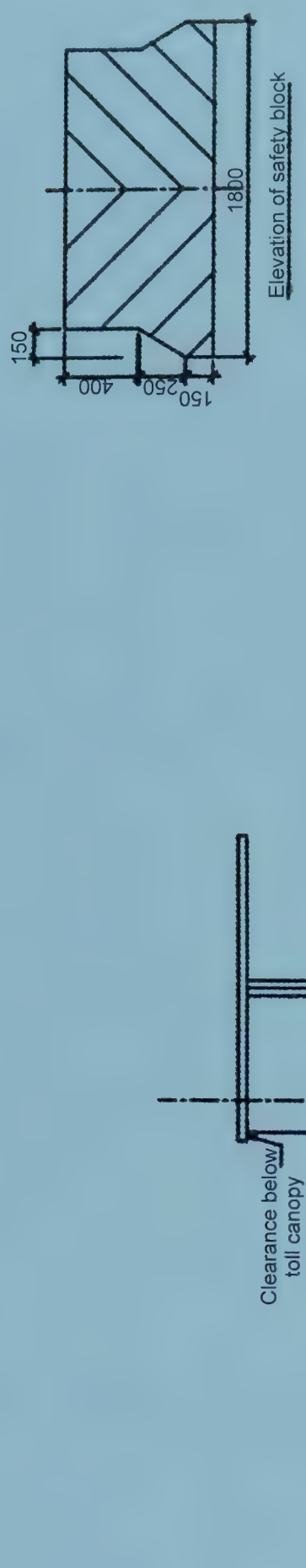
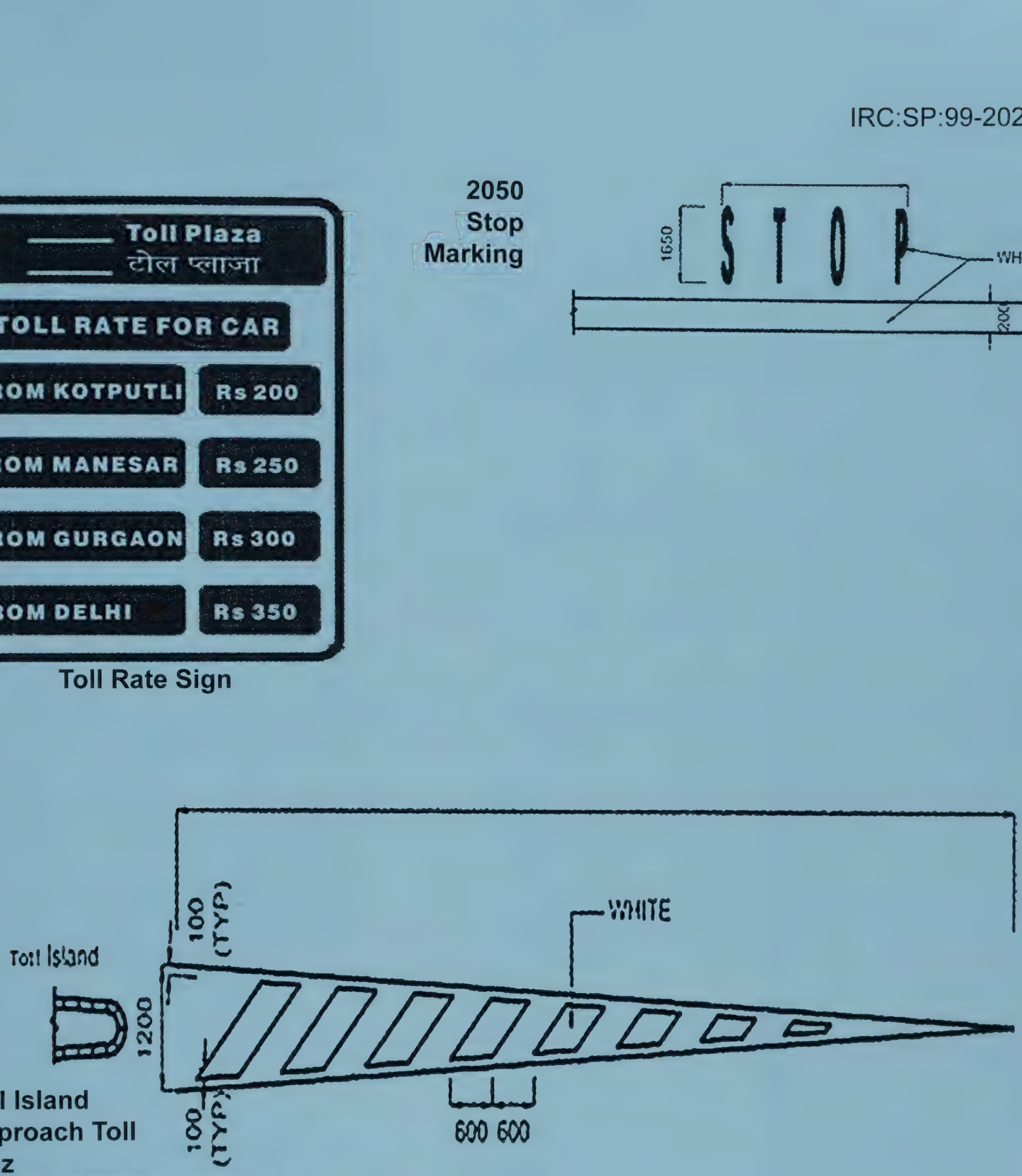


Fig. 12.5 Typical Layout for Traffic island with Toll Booth

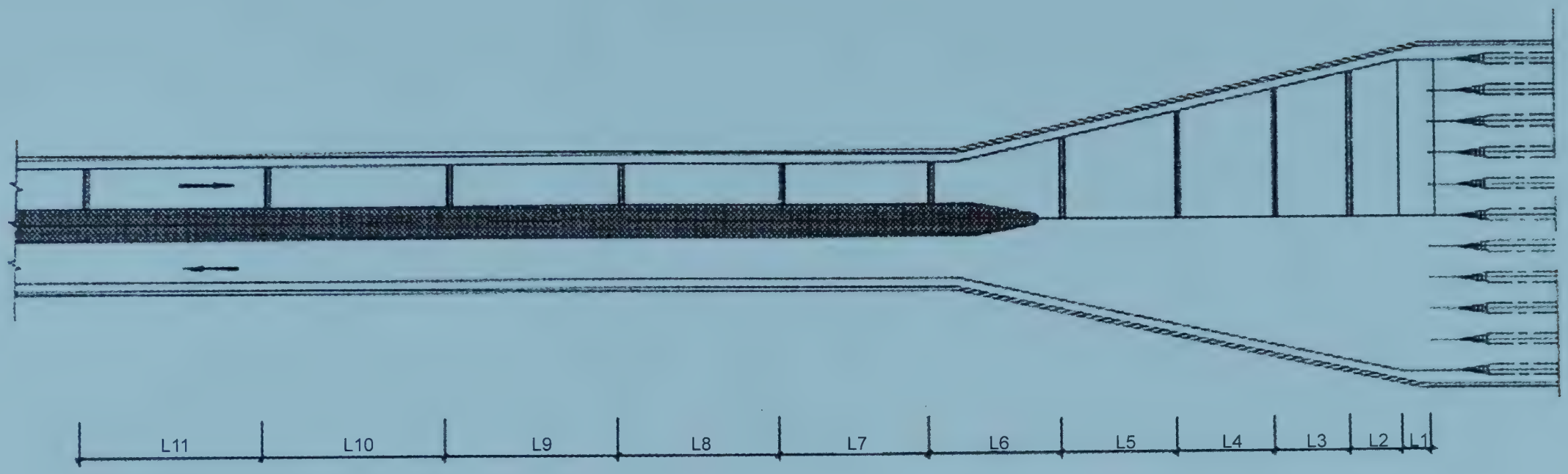
Toll Rate Sign

2050
Stop
Marking

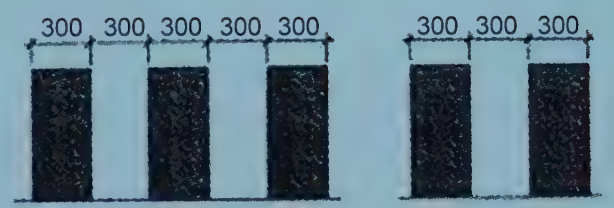


Toll Island
Approach Toll
Plaz

Fig. 12.6 Traffic Signs and Road Marking in Toll plaza



Distance from previous bar marking (m)	No. of bar marking
L1=5	1
L2=9	1
L3=13	2
L4=17	2
L5=20	2
L6=23	2
L7=26	3
L8=28	3
L9=30	3
L10=32	3
L11=32	3



White transverse bar marking

Note:
Detailed system of road marking as per IRC:35.

Fig. 12.7 Details of Suggestive Transverse Bar Marking for Speed Control at Toll Plaza

Annexure-A

(Refer, Para 12.4.2.1)

1. ETC Equipment

Sr. no.	Item/Description	Unit	Quantity
	I - Lane Level equipment - ETC Lanes		
1.	ETC RFID transceiver near Pay-axis - mounted on canopy	No.	1 per lane
2.	AVC including sensors, loop and detector	Set	1 per lane
3.	User Fare Display with mounting pole	Set	1 per lane
4.	Automatic Barrier Gate	No.	1 per lane
5.	Overhead Lane Status light (OHLS)	No.	1 per lane
6.	Traffic light with mounting pole	Set	1 per lane
7.	Loops with detector	Set	2 per lane
8.	Incident Capture Camera with mounting pole	Set	1 per lane
9.	License Plate Image Capture Camera with mounting poles	Set	1 per lane
10.	Violation light & Alarm (on existing pole) and Foot switch in booth	No.	1 per lane
11.	Medium Speed Weigh in Motion	No.	1 per lane
	II - Plaza Level equipment		
1.	Plaza Servers in hot-standby configuration	No.	1 per plaza
2.	Static Weigh Bridge (on Entry Side)	No.	1 per plaza
3.	Workstations for MIS, Audit & LSDU (Lane status display unit in control room)	No.	2 per plaza
4.	Network Printer	No.	1 per plaza
5.	24 Port Network switch (Layer 3)	Job	2 per plaza
6.	Outdoor WiFi Access Point	No.	1 per plaza
7.	ETC Software	No.	1 per plaza
8.	Internet connection with minimum 2 Static IP	Facility	1 per plaza

9.	UPS system as required for completeETC Toll Plaza system (10 kVA or above)	No.	2 per plaza
10.	55" LED Display for CCTV Monitoring	No.	2 per plaza
11.	Network Video Recorder (NVR) for CCTV recording with 30-days of storage	No.	1 per plaza
12.	CCTV cameras for Plaza building surveillance (server room, control room, cash up room, admin)	No.	4 per plaza

Note: The ETC equipment to be procured from competent service providers as approved by Authority Engineer.

2. Software Specifications

i) General Requirements

This functionality shall meet the lane operation described in the subsequent sections.

ii) Transaction Data Format:

The following shall be the minimum data that make up an ETC transaction

- Transaction ID
- Tag ID (TID, EPC, and User Memory)
- Plaza and Lane ID
- Date and Time Stamp
- AVC Class
- Image of vehicle (JPEG)

iii) Transaction Processing

The System shall:

- Have functionality to feed in transaction data through RFID ETC reader, hand-held devices and manually entry of Registration no. of vehicles.
- Validate each transaction for completeness (e.g. possessing all the related information like Tag ID, Vehicle class etc.)
- Check for duplicate transactions (e.g. the same tag cannot be used in the same direction within a specified duration at the same plaza)
- Support generation of a wide variety of reports as given below but not limited to:

- Revenue reports
- Traffic reports (Lane wise all mode of traffic report)
- Penalty Collection report lane wise
- Daily / Weekly / monthly reconciliation reports
- Violation reports
- AVC Accuracy Report
- Separate ETC report for Handheld reader
- Equipment uptime reports (RFID Reader, AVC, , LPIC, ICS and Server)
- Scalability

The System / Servers shall be scalable to support increase in Tag Users / ETC transactions in future. During the time of system commissioning each lane of the system shall be capable to support 5 million tag users and 30,000 (Thirty thousand) transactions per day and at the end of 5 years shall be capable enough to support 20 million tag users and 45,000 (Forty-five thousand) transactions per day.

- Automatic Lane closure

The ETC lane shall close automatically in case of detection of failure of critical equipment like RFID Transceiver, Boom barrier, LPIC camera, AVC system. In such cases the OHLS shall display that ETC lane is closed and the ETC exit barrier shall remain closed.

3. *Toll Plaza Equipment Specifications*

The subsequent sections capture the specifications of various equipment that may be required as a part of this project. Please note that this is in exhaustive list of all ETC equipment and the entire set may not be required in the current phase. Applicants are requested to refer to the detailed BOQ captured in the preceding sections of this Annexure. Also, the specifications are a minimum standard, and the supplier may choose to include products with specifications that exceed the standards, post approval from the Authority

3.1 ETC RFID Reader

Concessionaire is free to choose any brand of ETC RFID transceiver as long as it satisfies the functional requirements prescribed by the Authority as below:

A) Functions

Each ETC lane shall have one ETC RFID Transceiver. The ETC RFID Transceiver shall be mounted at least 5.5 meters above the finished road level. The Concessionaire shall

provide cantilever pole (if required), brackets, fixtures and other accessories necessary for the installation of the RFID Transceivers.

The operator shall design the installation method of ETC RFID Transceiver and decide the height of the RFID Transceiver within the applicable laws and regulations. But in no case, the clearance from the ground level shall be less than 5.5 meter.

B) Specifications

Description	Specifications
RF/radio:	
Frequency	UHF 865 to 867 MHz
Communications	Ethernet/Serial communication (EIA standard RS 232 C/ RS 485)
RF Power	4 W – EIRP (Equivalent Isotropically Radiated Power) / Equivalent
Reading distance	With the Transceiver mounted typically at a height of 5.5 m above the road surface, the coverage of the antenna shall not exceed a diameter of 3.6 m
Antenna	Circularly/Linear Polarized
Protocol	EPC Gen 2, ISO 18000-6C and shall comply with the general conformance requirements of the standard
Visual diagnostics	The Transceiver shall have LED indicators for sense; transmit Fault and Power which shall be visible clearly to the operator on ground while the system is operational.
Environmental:	
Enclosure	Light weight enclosure for the RFID Transceiver and circularly/ linearly polarized antenna
Environmental	IP 65 or better for outdoor units
Relative Humidity	95% Condensing
Description	**Specifications**
Operating Temperature	-20°C to 55°C
Storage Temperature	-40°C to 65°C
Operational Characteristics:	
Air Interface & Adaptive Noise Features	The Transceiver technology employed should have the capability to optimize read rates for the vehicle identification application and adapt to instantaneous noise and interference level.

Application capability	1. Should have read reliability exceeding 99.5% in the distance range specified. 2 Diagnostic and Reporting Tools.
Upgradeability	The firmware should be upgradable to support future protocols.
Transaction Capability	Reading of Tag & EPC memory for at least 2 Tags per second for a moving vehicle with a speed limit of 40 kilometres/ hour.

3.2 Automatic Vehicle Classification (AVC) System

The AVC system shall be able to distinguish between pre-defined classes of vehicle. This information shall be transmitted to the lane computer, and simultaneously to the LSDU (Lane Status Display Unit) database system, on completion of AVC classification. The lane computer will match this information with the classification from the ETC tag/Mapped Class of the vehicle. If there is a discrepancy between the two classifications, the incident capture camera shall be triggered to capture a digital image of the vehicle.

The classification hardware can be combination of the following:

i) Height sensors, axle counters

ii) Inductive loops, or

iii) Vision/Camera and AI based

The choice of classification hardware rests with the Concessionaire. The Concessionaire can propose a better proven combination of above-mentioned classification methods.

i) Accuracy Level:

The AVC system shall be 100% auditable and accuracy of vehicle counting should be 99.5% and classification accuracy shall not be less than 98%.

ii) Auditability:

The AVC System shall comply with the following auditability criteria:

- Each transaction recorded by the system shall be uniquely and sequentially numbered.
- The AVC shall be able to provide information to a computer connected to the same network as on AVC computer that shall be used for auditing the classification of the AVC as well as the classification of the lane operator.

i) For audit purposes, it shall be possible to enable all transactions as incidents in order to grab LPIC images and ICS image for Supervisor / Auditor review per lane / direction / all lanes.

ii) Description and Functions

- The automatic vehicle classification equipment shall be installed in the lane after pay-axis.
- The purpose of the AVC is to sense the presence of a vehicle (differentiate it from non-vehicular crossing), to measure and interpret certain physical characteristics of the vehicle as it passes through the AVC.
- The AVC shall be able to generate trigger to capture image/profile which shall be used for auditing purpose.
- The AVC shall be able to distinguish between classes as per the applicable notifications of MoRTH
- This class information shall be stored locally at AVC level and communicated to the System. Simultaneously a still image of the vehicle shall be captured / grabbed by the Incident Capture System (ICS) Camera as the vehicle triggers the AVC sensors. The System shall then check whether this AVC class matches the vehicle class (the CCH Class mapped to the Toll Plaza class) as read from the tag. If there is a discrepancy between the two classifications, the license plate image (captured when the vehicle passed through the ETC exit) and the ICS camera image shall be saved and stored with all transaction and incident information. The images and discrepancy information shall be communicated to the Local ETC server for further action and processing by the toll supervision staff.
- The AVC shall be capable of detecting and reporting the following vehicle movements and incidents in the lane to the server:
  - ♦ The AVC system must be able to count and distinguish two wheelers, autos and four-wheelers separately.
  - ♦ Vehicle Standing – the vehicle presence sensing equipment stays active for longer than a preset time. The preset time shall be parameter settable.
- All AVC elements (loops, Profiler based sensor, cameras, etc.) shall be fully weatherproof and installed in a location where vehicle damage by accident is not possible.
- When communication between the system and the AVC is severed, the AVC shall record the last transaction number transmitted and shall be able to independently count and record (store) vehicle classes passing through or over it. A sequential vehicle counter at AVC level shall be implemented to reconcile. The AVC shall have its own battery backup and data extraction facility on a computer.
- The AVC shall be able to generate violation if the ETC lane is not logged- in and a vehicle passes through it.

- In following cases, the AVC shall generate an alarm on the plaza level and send record to incident control system for supervisory action apart from the incidents defined:
  - ♦ Degraded classification (in case of any single Transmit / Receive failure)
  - ♦ Unable to classify
- The accuracy of the AVC shall not be affected by temperature or any weather / environmental conditions and shall be independent of vehicle speed / weight.

3.3 User Fare Display

A) Functions

- The User Fare Display (UFD) shall be located in the toll lane in a position where it is readily visible to and readable by Users from the pay point. The display has the primary purpose of informing the User of the vehicle. It shall convey ETC balance information & low balance warnings, public relations and seasonal messages.
- The UFD shall be of variable message type and shall have high intensity LED or similar operator approved display of 10 characters per line in two lines with the option of scrolling for displaying seasonal messages.
- The UFD shall send status information to the system for interface with plaza.

B) Specifications

Description	Specifications
Size	750 mm x 400 mm
Display	Red LED
Visibility Range	10 m
Enclosure	MS
Description	**Specifications**
MTBF	50,000 hours
MTTR	Less than 30 minutes
Protection	IP 65

3.4 Automatic Barrier Gate

A) Functions

The function of the Automatic Barrier Gate is to control the passage of vehicles through the lane. Each lane shall be fitted with a barrier gate.

The operation of barrier is linked to the lane controller. It allows the vehicle to pass through after a successful transaction has happened at the lane.

The system consists of a fixed housing and a movable arm with a high impact breakaway device or provision. The housing shall contain the motor and control units along with the integrated metal detectors for vehicle detection purpose. The housing shall be installed on the right side of the traffic direction, after the booth on a concrete base.

The boom arms shall be fitted with a swing-away flange to prevent damages to the barrier/ vehicle in case of an unpermitted or forced drive-through. Boom contact shall be available which gives continuous alert to the TMS when the boom is missing or swung away.

B) Specifications

The Automatic barrier gate shall meet the following technical specifications:

i) The lane exit barrier shall be suitable for high-speed ETC transactions. One full open-close cycle shall not take more than 1.2 seconds. The barriers used shall be capable of full lane open from a close state in less than 0.6 seconds.

ii) The housing and any mounting frame shall be fabricated from corrosion-resistant materials. They shall be IP 55 rated. The barrier shall be driven electrically. The motor shall not be damaged when the barrier is blocked in any position. Exit barriers shall have presence detectors to prevent barrier arms coming down on vehicles while passing. This shall be in the form of infrared units and dedicated embedded loops. Apart from the barrier arm, the mechanism may not have any moving protrusions that pose a risk to persons standing in close proximity to the barrier.

iii) The barrier arm shall be fabricated from a light, corrosion resistant material readily and inexpensively available in India. The barrier arm shall further have a protective mechanism whereby controlled fracture of the barrier arm occurs without damage to the housing or motor in the event of frontal collision. Preference will be given to non-destructive break-away mechanisms. Further, there shall be a protection mechanism to detect the presence of vehicles to avoid accidental hitting on the vehicles, whenever the boom is triggered for closing.

iv) Barrier arms shall have retro-reflective red stripes in accordance with the local traffic sign standards with soft cover to avoid damage to vehicles.

v) The Automatic Barrier Gate shall be IP 55 rated.

vi) The following minimum specifications shall be met:

Boom Length: 3/3.5 m

Boom Material: Aluminum

3.5 Overhead Lane Status Sign (OHLS)

A) Function

- The Over Head Lane Sign (OHLS) is located above the centre of the lane at the lane entrance. The purpose of the OHLS is to indicate to the User whether the toll lane is open for the processing of vehicle or closed. A red cross is used to signal that the lane is closed, whilst a green arrow is used to indicate that the lane is open to traffic.
- Signs must be sufficiently bright and directed to indicate to a motorist, approaching the toll plaza, at a distance of 300 m on a bright cloud free day that the lane is available for use. The OHLS status shall also be visible up to a peripheral view of 45 degrees from the travel axis.
- At any situation, both RED and GREEN part shall not glow simultaneously. Under failure conditions, only Red Cross shall be displayed until rectification.

B) Specifications

The following minimum specifications shall be met:

Description	Specifications
Size	300mm X 300 mm
Display (Cross)	Red LED
Display (Arrow)	Green LED
Description	**Specifications**
LED	5mm in diameter, 8000 mcd
Visibility Range	300 m
Enclosure	IP 65

3.6 Traffic Light with mounting pole

A) Functions

- The Traffic Light (TL) shall be located in the toll lanes in a position where it is readily visible to users of the toll road, usually on the side of the lane beyond the toll booth. The traffic light shall consist of two traffic light heads mounted on a suitable pole. An amber signal with arrow is used to indicate that the user should take suggested path, whilst the green signal is used to indicate that the user should proceed.
- At any situation, both AMBER and GREEN part shall not glow simultaneously. Under failure conditions, only Amber arrow shall be displayed until rectification.

B) Specifications

The following minimum specifications shall be met:

Description	Specifications
Size	200 mm
Display (Stop)	Amber LED
Display (Start)	Green LED
Visibility Range	20 m (under normal visibility conditions)
Enclosure	SS or polycarbonate
Protection	IP 65 rated

3.7 Loops with Detector

Dimension as suggested by the Service Provider/System Integrator and detector specification as per AVC specification chapter.

3.8 Incident Capture Camera

A) Functions

- The cameras shall be charge coupled device (CCD) colour cameras equipped with fixed/variable focal, manual/automatic iris lenses and night vision capabilities. The cameras shall require a minimum of 1.8 lux for usable image/video. The CCTV systems shall have adequate surge and lightning protection.
- The model selected shall have image compensation capability to ignore stray lighting/ vehicle lighting so that ICS and LPIC shall render meaningful output for verification. The camera should have features like digital WDR, HLC, BLC to compensate the low or extra light in the view.
- The camera should be able to capture snapshots also.
- Camera Location

The best mounting positions for the cameras must be determined so that effects, such as, direct sunlight and stray lighting is negated. The cameras shall also be protected from or be resistant to high winds and moisture. Vibration shall be minimised such that the image quality is never compromised.

Each camera shall view and detect vehicle images for its lane. The cameras shall be located so that sidelong profile of the vehicle is obtained as it crosses the AVC, so that the number of axles of the vehicle crossing the AVC shall be clearly visible when the vehicle is exiting the lane. The camera shall have an automatic adjustment of brightness. The housing shall be an IP-65 rated Enclosure to withstand adverse weather conditions.

3.9 Automatic Number Plate Recognition Camera

- Each camera shall view and detect vehicle images for its lane. The cameras shall be located so that front profile of the vehicle is obtained as the transaction is processed. The camera shall have an automatic adjustment of brightness. The housing shall be an IP-65 rated Enclosure to withstand adverse weather conditions

- The camera shall be installed inside the housing at the suitable height above the surface of the lane to be decided by the Concessionaire on a pole to allow the automatic number plate recognition and capturing of the vehicle in the lane.

The model selected shall have image compensation capability to ignore stray lighting/ vehicle lighting so that ICS and LPIC shall render meaningful output for verification. The camera should have features like digital WDR, HLC, BLC to compensate the low or extra light in the view.

3.10 Network Switches

A) 24 Port Layer 3 Switch with 4 Fiber Port

i) Switch shall have minimum 24 nos. 10/100/1000 Base-T ports and additional 4 nos. SFP uplink ports loaded with MMF modules with dedicated stacking ports.

ii) Switch shall have wire rate performance and 48 Gbps of dedicated stacking bandwidth.

iii) Switch should support port security, DHCP snooping, Dynamic ARP inspection, IP Source guard, BPDU Guard, spanning tree root guard.

iv) Switch should be IPv6 Certified/IPv6 logo ready and Switch/Switch's Operating System should be tested and certified or in process of certification for EAL 2/ NDPP or above under Common Criteria Certification.

v) Switch should have 1:1 redundant internal power supply. Power supply modules, fan modules and transceivers modules should be hot swappable.

vi) Should support IEEE Standards of Ethernet: IEEE 802.1D, 802.1s, 802.1w, 802.1x, 802.3ad, 802.3x, 802.1p, 802.1Q, 802.3, 802.3u, 802.3ab, 802.3z, 802.3az

B) 8-Port PoE industrial grade rugged managed switch with 2 fibre port shall be provided in each lane to connect all lane peripherals. No unmanaged switch shall be provided in the HES lane. This 8-Port switch shall be installed inside the Electronic Enclosure of the Hybrid Lane Controller. Managed switch will ensure that the data transmission between the lanes and PMS is smooth and faster. This will also prevent data broadcasting from lanes which may result in chocking of the entire network and slows the data transfer and efficiency of the lane equipment.

3.11 ETC Server (Plaza Server)

The local ETC server is responsible for the control, data storage, processing and administration of the toll operation. It shall be the responsibility of toll management server to synchronize all activities of toll collection process, data and time of all workstations

Description	Specifications
Form factor/height	2U Rack
Processor	4 - core Intel Xeon E5-2600 v2 series processors - 2 Nos. or better
Cache	15 MB per processor or Better
Memory	32 GB RAM, DDR 4, Shall be expendable to 64 GB
Internal Storage	Minimum 8 TB SAS/SATA or Better
RAID support	Integrated 6 Gbps or new optional 12 Gbps* hardware RAID-0, -1,-10 with optional RAID-5, -50, -6, -60
Power supply (std/max)	2 - Redundant Hot swappable
Hot-swap components	Power supplies, fan modules and hard disk drives
Network Interface Controller (NIC) Trusted Platform Module (TPM)	4 × 1 GbE (std.), 2 × 10 GbE Embedded Adapter (slot less opt.)/TPM
PCIe 3.0 Expansion slots (x16/x8)	4 - 6 PCIe ports or 4 PCI-X (CTO) or 2 double-width PCIe (forGPU)
USB ports	2 front/4 back/2 internal
Internal storage	Minimum 8 TB SAS/SATA or Better
Energy-efficiency compliance	80 PLUS® Platinum and ENERGY STAR® Compliance
Monitor	18.5" LED
Input interface	Keyboard and Mouse
Operating System	Windows Server 2016 Std.(or higher) or Open source OS such as Linux, Unix flavours, as per requirement of Toll Management System.

i) Database Management System

- Database shall be a relational database management system.
- Lane system shall not have any direct database access. Data from the lane going to the database shall be through dedicated software that runs on database server.

3.12 Workstation

A) Functions

The workstation will be used by the System Administrator and/or Toll Supervisor to access the system for Admin/Audit purpose. At least 4 work stations/laptops should be provided in the Plaza office/Control Room with following minimum specification.

B) Specifications

The TMS workstation shall comply with the minimum specifications prescribed in the below table.

Description	Specifications
Processor	Latest Intel Core Processors
Memory(RAM)	4 GB or better
Storage	1 TB or better
Network	Integrated NIC
Ports	RJ-45, 1 USB 3.0, 3 USB 2.0
Monitor	18.5"LED
Input interface	Keyboard and Mouse
Antivirus	Yes

3.13 Network Laser Printer (Black and White)

A) Specifications

At least 1 Network Printer shall be required in the Plaza office/Control Room with following minimum specifications:

- 25 PPM
- Duplex;
- Fast Ethernet; and should support Paper size(s): Letter/Legal/Executive/ Statement/8.50" x 13"/Envelope No. 10/Monarch Envelope/Custom Size.

3.14 Medium Speed Weigh-in-Motion

A) Functions

i) The MSWIM system shall be able to capture number of axles, axle spacing, number of wheels, gross weight of vehicle and height of each passing vehicle and provide data of each vehicle to the lane controller for further auditing and analysis.

ii) The Gross Vehicle Weight of vehicles approaching the toll booth shall be automatically detected for speed range prescribed in the specifications.

iii) If the vehicle is found to be overloaded based on Toll Collector Classification, the Weight information shall be displayed as "Overweight Warning" and such vehicles shall be dealt as per applicable policy for the project.

B) Specifications

Description	Specifications
Capacity of the Platform	30 Ton/Axle
Stationary Accuracy	±0.1% FSR
In Motion Accuracy	±7% FSR up to speed 50 Km/h; and
Overload capacity of the platform	150% of rated capacity
Vehicle separator	IR Based curtain housed in Weather Proof, IP 65 Rated pillars with proper sealing
Controller Housing	Water/ weather proof with anti-rust coating; IP 65 rated
Approval/ Certification	Weights & Measures Approved Model, Duly stamped & sealed by W&M Department on Installation
Re-calibration/ Stamping & Verification	Every 12 (Twelve) months
Downtime allowed for Periodic Maintenance	Maximum 24 (Twenty Four) hour/ Quarter

3.15 Static Weigh Bridge

The handling of overloaded vehicles shall be governed by terms of directives issued by the Authority.

A) Functional requirements

i) A Static Weigh Bridge (SWB) shall be installed in each direction of traffic, after the toll plaza, in a separate area having facility of parking of overloaded vehicles. This is to ensure that an overloaded vehicle does not ply on National Highways Expressway.

ii) The SWB system shall be able to capture Toll Transaction Number with Date and Time, Vehicle Registration Number, Category of Vehicle, Permissible Weight, and Gross Vehicle Weight along with date/time of weighing, and the receipt printed

by the SWB system shall contain these information. This system shall also be integrated with the toll system and generate a closure report.

iii) The SWB station shall have a CCTV camera for capturing image of vehicle while weighing.

iv) Monthly MIS reports shall be available for the Authority, such as Actual Over loaded vehicles, Total Overweight Vehicles (WIM) vs Actual Overweight vehicles (SWB) etc.

B) Technical Specifications

Type	Site specific (Pit/Pit less/mobile)
Body/Platform	Steel
Size	18 meter x 3 meter
Capacity	120 Tonnes
Structure	I-Beam complying BIS 2062. Top Plate - 10 mm or more – Steel as per BIS 2062
Structure	Duly certified for Structural Analysis And Design(STAAD)-III
Number of Load cells	8
Type of Load Cells	Compression Type/Double Ended Shear Beam – Stainless Steel 17-4 Ph
Protection Class for the Load Cells	IP 68 or better, Operational Temp: -10 to 65 Degrees
Protection Class for the Weighing Indicator	IP 65 or better, Operational Temp: -10 to 65 Degrees
Overload capacity	150% of rated capacity
Accuracy Class	OIML - C-IV
Accuracy Tolerance	Up to 0.02%
Painting	Anti-rust & anti-corrosion painting
BIS Specification	IS-9281(Part-III)
Compliant	Legal Metrology Act 2009 (1 of 2010) & Rules framed there under from time to time - Duly sealed by the Weights & Measures Dept.
Approval/ Certification	Weights & Measures Approved Model

3.16 UPS System

A) Specifications

Online UPS with 4 hours of backup and sizing based on power requirement calculation, shall be provided. The UPS design shall take the following into account:

i) The system shall be capable of maintaining an uninterrupted power supply to the UPS loads for a sustained period of at least 4 hours under full load conditions from a fully charged battery.

ii) It shall also be capable of continuously supplying power to the system under an intermittent interruption cycle.

iii) The UPS shall be capable of operating at input voltages of 210/380Volts ±10% and 50 Hz ±2.5 Hz.

3.17 Cabling

A) Specifications

All cables and wires shall be of good quality, conforming to normally accepted industry standards, and shall be of the proper type and have sufficient ratings for the particular application.

All exposed ends of unconnected cables and wires shall be coated with water tight sealing compound or sealing tape to avoid damage to conductors. All communication cables used shall have a clearly marked label securely fixed near each end in accordance with the cable network diagram.

All cables and wires shall be adequately protected from the edges of equipment housing or other surrounding objects. All the cables and wires shall be neatly arranged and securely placed in such a way that all terminals are relieved of the weight of the cables. Terminals shall be coded and identified as per the wiring diagrams. Live metal shall be recessed or protected to avoid accidental contact.

SECTION 13

PROJECT FACILITIES: SERVICE AREAS, PICK-UP BUS STOPS, STATE BORDER CHECK POSTS

13.1 Service Areas

13.1.1 *Introduction*

Service areas shall be planned and provided as wayside amenities for users of the expressways to enable them to stop, take rest and refresh themselves so as to ease their fatigue. These areas also cover facilities for providing fuel for vehicles and emergency requirements without having to exit from the expressway. Thus, provision of service areas and their operation and maintenance are to be an integral part of the Project Expressway for comfortable and safe driving.

Service Areas shall be provided at interval of around 50 km. The area shall be sufficient to accommodate parking, toilets, eating facilities, petrol pumps, repair shops, some green areas for recreation, and traffic information kiosks. The entry and exit to the Service Areas shall be through auxiliary lane and the layout shall be such that the approach to the facility is short, circulation areas for vehicles and people are comfortable and service time is quick. There has to be sufficient frontal clear areas in front of facility building to steer clear of the stopped vehicles, drop the passengers, access the parking lot and circulate easily for accessing the facilities and exiting the Service Area. Less the circulation time for passengers and vehicles and the Service time at the facilities, more efficient is the functioning of the Service Area.

The size of the facility shall be decided on the basis of the demand for passengers to use the facility and remain in the Service Area for being served. It may be assumed that 10 to 15 per cent of the users may use the facility and remain there for a duration varying between 15 to 30 minutes. For example, at the minimum level of 10 to 15 minutes usage by 15 to 10 per cent traffic for a flow level of 3000 vehicles per hour, the parking demand will be for minimum of 75 cars [(3000/(60/1015)x (1510/100)=75]. Assuming car occupancy as 2 per car, the eating facility required would be such that at any point in time it would remain occupied by 150 persons, each of whom has to be served within 10 to 15 minutes. Same would go for toilet usage. For 15 to 10 (150/10 to 15) persons arriving per minute and average toilet usage time of 2 minutes only 7.5 5 persons can be served in each cycle of usage, and if 8 to 6 service units are provided, there would be no queue.

13.1.2 *Site spacing*

i) The service areas may be planned at approximately 50 km intervals (This may correspond to roughly 45 minutes of driving). Location of service areas shall be as given in **Schedule C** of the Concession Agreement.

ii) In addition to the regular service areas, only toilet facilities are also required to be provided. Their locations may be approximately half way (midway) between the service areas. These toilet facilities may be on short laybyes off the expressway shoulders but with proper deceleration and acceleration lanes. Further, such laybyes may not be located on sharp curves or inside of curves. Location of laybyes for toilet facilities shall be as given in **Schedule C** of the Concession Agreement.

13.1.3 *Service facilities*

The principal users of the expressway are passenger car users, bus users, goods vehicles drivers and other attendants. The service area shall provide the following facilities for the expressway users.

a) For Vehicles

i) Parking lot: Separate lot for cars, buses and trucks including multi Axles

ii) Fuel station: Provision for Petrol, Diesel, CNG, Oil, Air, etc.

iii) Garage: For minor repairs and service for vehicles

b) For Passengers/Drivers

i) Walkways and access roads: Internal circulation, connecting parking lot with toilet blocks and other facilities, access road from/to the expressway

ii) Green spaces/lawns: May also include picnic tables, benches

iii) Toilets: Separately for men, women and physically challenged

iv) Kiosks: For cold drinks, water, eatables, public information, photos, batteries, ATM

v) Restaurant/Fast food: Cafeteria, meals, fast food, handwash, (preferably, separate area be earmarked for truckers)

vi) Cubicles, dormitories: Some space for rest and longer stay (especially for truckers). Some space for child care.

vii) Business lounge: Cubicles for internet, fax, photocopying

viii) First Aid: Nursing Aid

ix) Waste receptacles: Bins for waste disposal

x) Others: Toiletries, medicines, tourist information

c) For operation and maintenance of service area

i) Water storage tank, recycling of waste water

ii) Electricity supply

iii) Incinerator

iv) Service roads

v) Sewage disposal

vi) Staff room for O&M personnel

vii) Parking for O&M personnel

13.1.4 *Site location*

a) The location may be decided keeping in view factors such as scenic attributes, availability of utilities (potable water, waste water disposal, telephone and electrical service), potential environment impact, availability of adequate right of way (ROW).

b) The site should not be less than two km from an interchange unless the site itself is planned and provided as an interchange-cum-service area.

13.1.5 *Size*

a) The size of the service area would depend mainly upon the number of parking spaces needed for cars, buses and trucks. This would be a function of Average Daily Traffic and likely percentage of traffic wishing to stop by the service area. **Annexure-B** gives broad guidance for assessing number of parking spaces. The size of other facilities like toilets, cafeteria, restaurants for passengers and drivers, lawns, walkway, road access and service facilities would be linked to the number of users on the one hand and availability of land and topography of the area on the other.

b) The size of the service area would be sum total of areas required to provide the magnitude and level of facilities and amenities indicated in **Para 13.1.3** above. A minimum area of five hectares shall be provided. The service area upto fifteen hectares is considered generally manageable and this will provide enough space for landscaping and allow for future expansion requirements with growth of traffic on the expressway.

c) The services of a competent and experienced landscape architect and a transportation professional are essential for assessing the requirements of each of the facility component indicated in **Para 13.1.3** above and working out suitable layout. Factors such as separation of facilities for passengers and truckers, walking distance from parking lot to toilets, restaurants, etc. and relevant byelaws of local bodies including fire safety, environment, aesthetic and landscaping aspects shall be considered while designing and preparing the layout and design. Typical layouts are indicated in **Fig. 13.1A** to **13.1F**.

d) Provision of toilets is another key facility which the users look for in service areas. Special care is required for provision of ventilation and light in toilet areas. Separate toilets need to be provided for the persons with disabilities. The number of toilet facilities will depend upon the number of users. No standard guidelines are available in this regard. **Tables 13.1** and **13.2** give the minimum requirements for these facilities linked to the ADT and composition of trucks in the total traffic.

Table 13.1 Number of toilet facilities for car and Bus Users

Percent Heavy Vehicles	ADT-20000 VPD				ADT-40000 VPD			
	Urinals	Men's	Women's	PwD	Urinals	Men's	Women's	PwD
30	8	4	8	2	14	6	12	2
40	8	4	8	2	14	6	12	2
50	6	4	6	2	10	4	8	2
60	6	4	6	2	10	4	8	2

PwD = Persons with Disabilities

Table 13.2 Number of toilet facilities for truck Users

Percent Heavy Vehicles	ADT-20000 VPD				ADT-40000 VPD			
	Urinals	Men's	Women's	PwD	Urinals	Men's	Women's	PwD
30	6	4	2	2	10	6	4	2
40	6	4	2	2	10	6	4	2
50	8	4	4	2	12	8	6	2
60	8	4	4	2	12	8	6	2

PwD = Persons with Disabilities

e) **Annexure-C** gives the provisions required for persons with disabilities, i.e. physically challenged persons.

13.1.6 *Design considerations*

For design considerations of various facilities, reference may also be made to MoRTH Guidelines for Expressways.

13.1.7 *Operation and maintenance*

a) An operation and maintenance plan shall be developed for the service area to ensure that various maintenance activities are appropriately considered as part of ongoing

service area operations. During construction, the equipment's installed, wiring diagrams, water lines, sewerage, pumps, septic tank, water coolers, lighting fixtures, etc. all shall be documented as to locations, types, models, etc. All these details should be included in the O&M Manual for the Expressway.

b) A list of emergency contacts with telephone numbers and addresses shall be kept and displayed at the service area.

13.2 Pick-Up Bus Stops

13.2.1 *Introduction*

The operators of bus services plying on the expressway would require facility of bus stops at important towns and village settlements en-route served by the expressway for enabling the passengers to either get down or to pick-up the passengers wanting to get in. Since the expressway is not open to pedestrians, the bus stops have to be located outside the Right of Way of the expressway to ensure safe and unimpeded travel.

13.2.2 *Location*

The pick-up bus stops shall be located at the inter-change points and planned in a manner that passengers are kept away from the expressway facility. The pick-up bus stops shall not be located in the Service Area except where the service area itself is planned at an inter- change point. The location of pick-up bus stops shall be as given in **Schedule C** of the Concession Agreement.

13.2.3 *Design philosophy*

Basically, the design and layout of the pick-up bus stops may be integrated with local bus services and intermediate public transport (auto rickshaws, taxis, etc.). Adequate transit facility shall be planned and provided accordingly. Being a closed system of tolls to be adopted on expressways, there shall be specially designed access road for buses exiting from the expressway to the bus-stop and thereafter entering the expressway such that the bus does not leave the access road except for letting the passengers get down from the bus or get into the bus from the pick-up bus stops. **Fig. 13.2** presents a typical functional arrangement of pick-up bus stops at the Expressway combined with local bus stop facility.

13.3 State Border Check Posts

13.3.1 *Introduction*

The state border check posts shall be planned and provided outside Expressway to enable the State Authorities to exercise checks as per Applicable Laws on the vehicles crossing the state border.

13.3.2 *Location*

The check posts shall be provided on laybyes off the Expressway shoulders with proper deceleration and acceleration lanes. Further, such laybyes will be located immediately after crossing the state border. The location of check posts shall be as given in **Schedule C** of the Concession Agreement.

13.3.3 *Design consideration*

The design of the check post will be undertaken in consultation with the State Authorities. Normally, a built-up area of 300 sqm would suffice including the toilet facilities. An open area of around 300 sqm adjoining the building block shall be reserved for parking of vehicles. Typical layout is given in **Fig. 13.3**.

ANNEXURE-B

[Refer Para 13.1.5 (a)]

Broad Guidance for Assessment of parking spaces in service Areas

1) The parking lots shall be provided separately for cars, buses and trucks in the same service area complex.

2) The number of parking spaces depend upon:

   - the total average daily traffic,
   - usage ratio, i.e. the ratio of vehicles likely to use the service area facility,
   - design hour factor, i.e. the peak hour volume in relation to the average flow
   - stay in hours

3) AASHTO, UK Department of Transport and JICA have formulated their own guidelines for assessment of parking lots in Rest Areas. Based on these practices, a simplified approach is given hereunder.

4) Find out the ADT of cars, buses and trucks only for the direction in which the Service Area lies for which the assessment is to be done.

   Then the number of parking spaces will be given by the equation. N = ADT x UR x DHF x L

   Where N = number of parking spaces

   ADT = Average Daily Traffic in the direction of service area

   UR = Usage Ratio

   DHF = Design Hour Factor L = Stay in Hours

5) The suggestive values of UR, DHF and L for cars, buses and trucks are given in **Table 1** below:

Table 1 Usage factors proposed

Type of Vehicle	Ur	Dhf	L	Number (N) of parking spaces (per 1000 VPD of a particular class in one direction)
Cars	0.15	0.10	30/60	7.5 per 1000 cars
Buses	0.20	0.12	24/60	9.6 per 1000 buses
Trucks	0.15	0.12	36/60	10.8 per 1000 trucks

6) An illustrative exercise is now undertaken for a total ADT of 40,000 VPD in both directions with four cases of traffic composition as per **Table 2** and **Table 3**:

Table 2 Broad Composition of Traffic

Class	Percent composition Assumed			
	case I	case II	case III	Case IV
Cars	75	70	63	50
Buses	5	5	7	10
Trucks	20	25	30	40

Table 3 Number of parking spaces for total Adt of 40,000 vpd in both directions

Percent of CVs			Number of parking spaces			
Case	Trucks	Buses	Cars	Buses	Trucks	PwD
Case I	20	5	114	10	44	4
Case II	25	5	106	10	54	4
Case III	30	7	96	14	66	4
Case IV	40	10	76	20	88	4

PwD = Persons with Disabilities

7) To begin with, minimum number of parking spaces may be provided considering an ADT of 20,000 VPD in both directions with scope for future expansion in tune with traffic growth and usage experienced at the particular Service Area. The minimum parking spaces to be provided shall be as per **Table 4** below:

Table 4 Minimum Number of parking spaces

Percent of CVs		Number of parking spaces			
Trucks	Buses	Cars	Buses	Trucks	PwD
20	5	60	5	25	2
25	5	50	5	30	2
30	7	50	7	35	2
40	10	40	10	45	2

PwD = Persons with Disabilities

Annexure C

[Para 13.1.5 (e)]

Provisions for Persons with Disabilities (PwD)

For this Manual, the disabilities mean which confine individuals to wheel chair for mobility.

The standard size of wheel chair as generally considered is 1,050 mm x 750 mm.

At the wayside amenity centres/rest areas, the level of the roads, access paths and parking areas require special considerations as described below:

Access Path/Walk Way: Access path from entry to parking lot and to facility centre shall be minimum of 1,800 mm wide having even surface without any steps. Slope, if any, shall not have gradient greater than 5 percent. Finishes shall have a non-slip surface with a texture traversable by a wheel chair as well as for trolley baggage. Kerbs wherever provided should blend to a common level.

Parking: For parking of vehicles, the following provisions are required:

- Surface parking for at least two Car Spaces shall be provided near entrance, with maximum travel distance of 30 m from facility entrance.
- The width of parking bay shall be minimum 3.6 m.
- The signage for reserved space for wheel chair users shall be conspicuously displayed using large sign boards.
- The slope of parking spaces reserved for **persons with disabilities (PwD)** on wheel chair especially should not exceed 1 (one) percent gradient. **Fig. 13.1G** presents typical layout.
- Ramp should be complemented by flights of steps, as many people (crutch users) have more difficulty coping with ramps than steps, particularly when descending.
- Landings – every 750 mm of vertical rise, width should be 1800 mm wide to permit wheelchairs to pass. Over short lengths, a minimum width of 1200 mm can be accepted. **Fig. 13.1H** presents typical arrangement.

Ramped Facilities: Ramp shall be finished with non-slip material to enter the facility. Minimum width of ramp shall be 1,800 mm with maximum gradient 1V:20H.

Exit/Entrance Door: Minimum clear opening of the entrance door shall be 900 mm and it shall not be provided with a step that obstructs the passage of a wheel chair.

Entrance landing: Entrance landing shall be provided adjacent to ramp with the minimum dimension 1,800 mm x 2,000 mm. The entrance landing that adjoin the top end of a

slope shall be provided with floor materials to attract the attention of persons (limited to coloured floor material whose colour and brightness is conspicuously different from that of the surrounding floor materials). Finishes shall have a non-slip surface with a texture traversable by a wheel chair.

Flooring:

- Tactile floor blocks should be provided to orient persons with low vision, vision impairment and deaf blind. These blocks should have a colour (preferably canary yellow), which contrasts with the surrounding surface.
- Guide path (line blocks) has straight continuous line and indicate the correct path/ route to follow, leading to building entrances, an amenity, bus stop etc. and should not be located close to manholes or drains, to avoid confusion for persons with vision impairments.
- Warning (dot/blistered blocks) strip provides warning signal to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction and to warn of a corner or junction. Should be placed 300 mm at the beginning and end of the ramps, stairs and entrance.

Lifts: Wherever lift is required, provision shall be kept for at least one space for the wheel chair, with the following cage dimensions (Bureau of Indian Standards). Clear internal depth of 1,100 mm, internal width of 2,000 mm and Entrance door width of 900 mm.

- A hand rail not less than 600 mm long at 1,000 mm above floor level shall be fixed adjacent to the control panel.
- The lift lobby shall be of an inside measurement of 1,800 mm x 1,800 mm or more.
- The time of an automatically closing door should be minimum 5 seconds and the closing speed should not exceed 0.25 m/s.
- The interior of the cage shall be provided with a device that audibly indicated the floor the cage has reached and indicates that the door of the cage for entrance/ exit is either open or closed.

Toilets: At least one special WC in a set of toilet shall be provided for the use of handicapped with essential provision of wash basin near the entrance.

- The minimum size shall be 1,500 mm x 1,750 mm.
- Minimum clear opening of the door shall be 900 mm and the door shall swing out.
- Suitable arrangement of vertical/horizontal handrails with 50 mm clearance from wall shall be made in the toilet.

- The WC seat shall be 500 mm from the door.

Drinking Water: Suitable provision for drinking water shall be made for the handicapped near the special toilet provided for them.

Signage: Appropriate identification of specific facilities within a building for the handicapped persons should be done with proper signages. Signs should be designed and located so that they are easily legible. To ensure safe walking, there should not be any protruding sign which creates obstruction in walking. Public Address System shall be provided.

The symbols/information's should be in contrasting colour and properly illuminated. A symbol for wheel chair shall be installed at the lift, toilet, staircase, parking areas etc. that have been kept especially for the purpose. **Fig. 13.1J** presents typical signages.

Other Facilities:

Fig. 13.1 I, K, L and M present other facility requirements at various usage places.

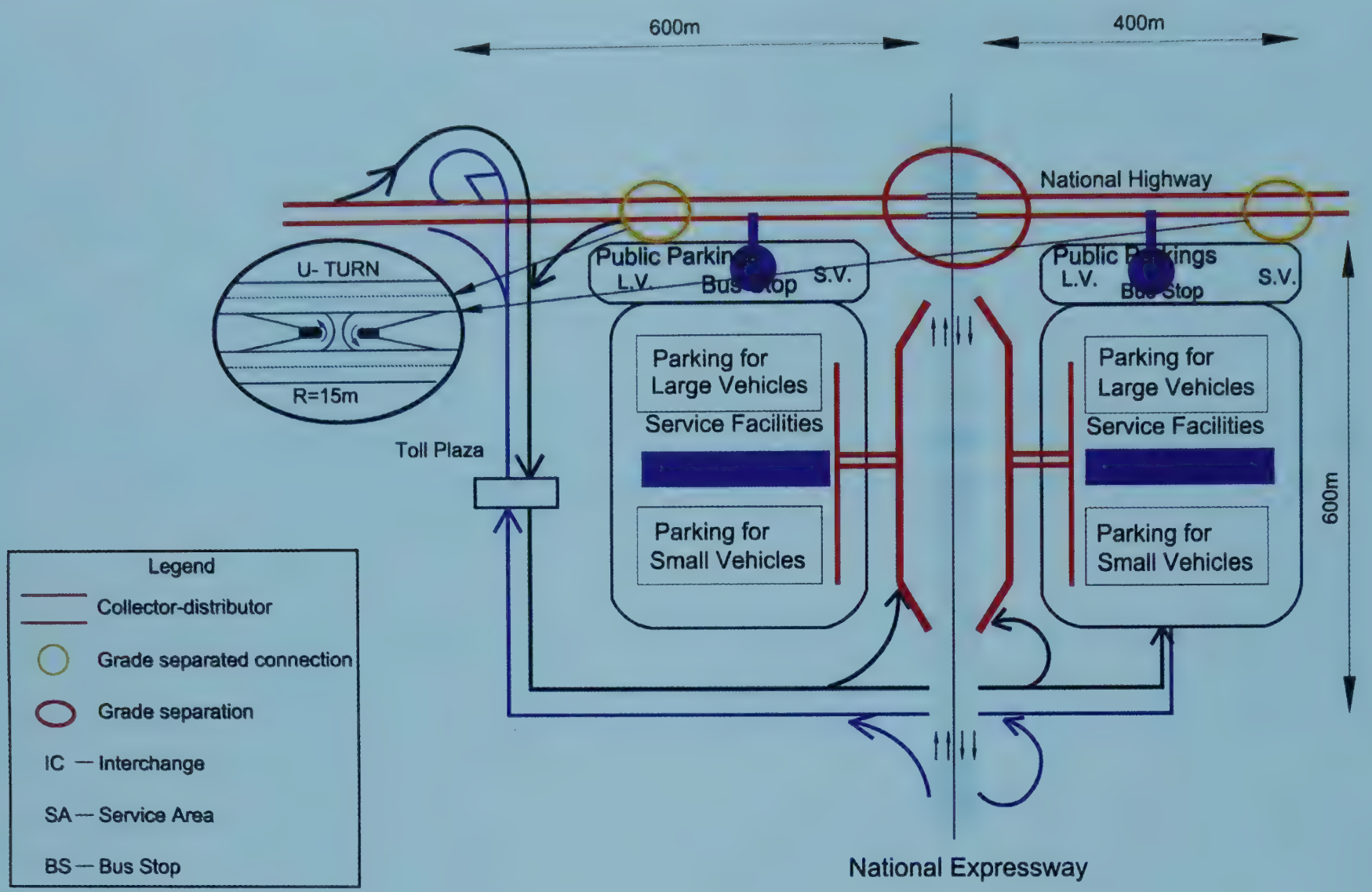


Fig. 13.1A Conceptual Drawing of IC cum SA cum BS

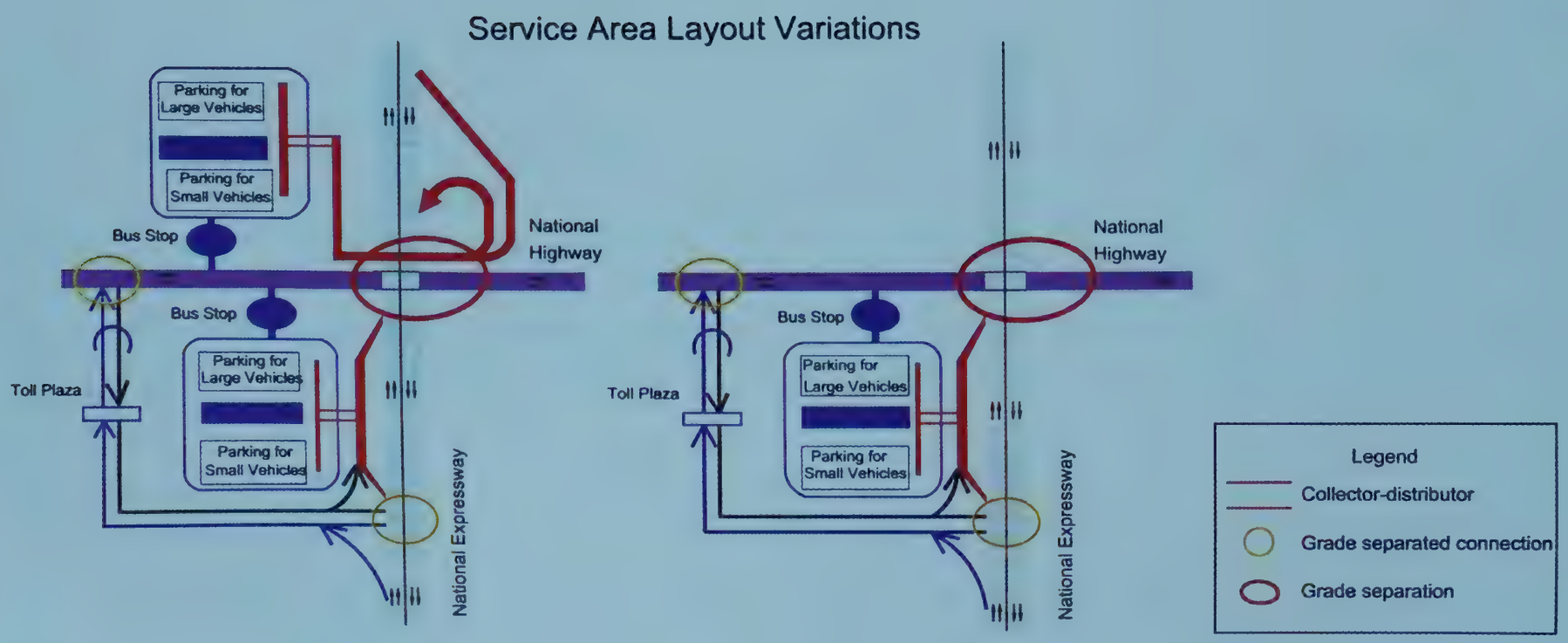


Fig. 13.1B One - Side Located

Fig. 13.1C One - Direction Service for Alternate Exit

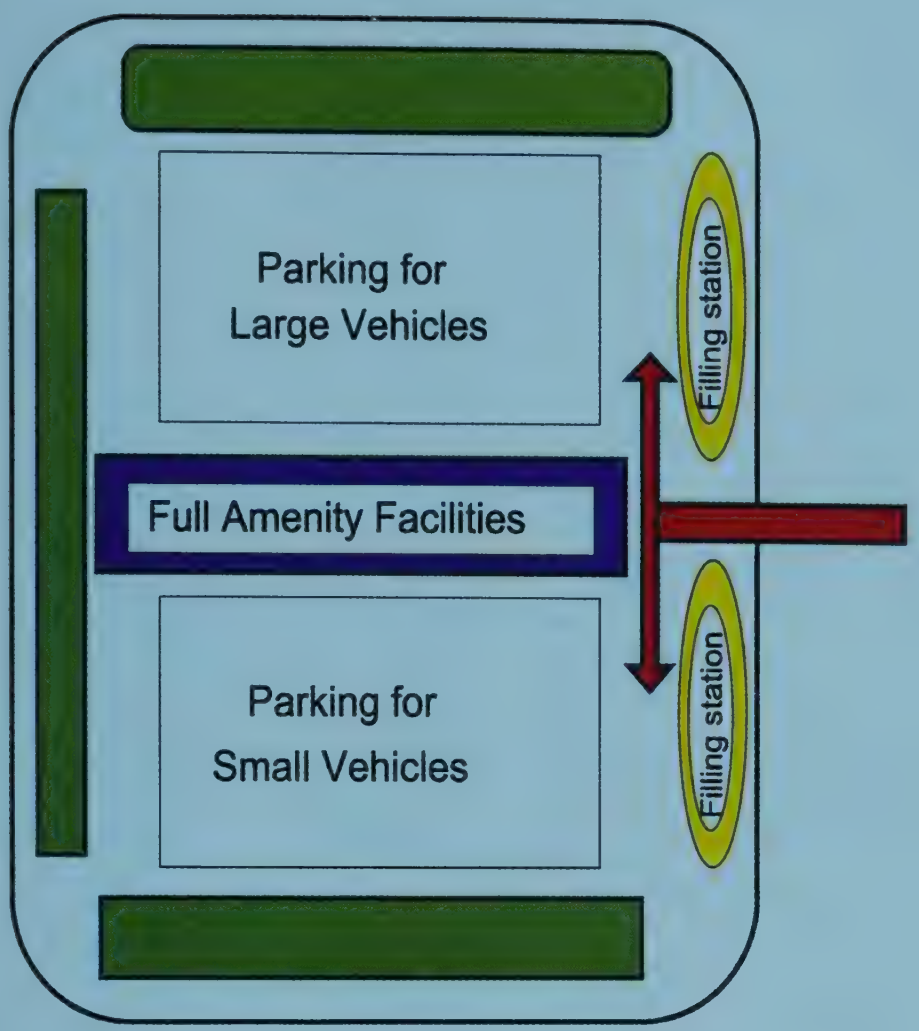


Fig. 13.1D Full-sized Amenity

(Stand-alone when spacing of Interchange > 40km)

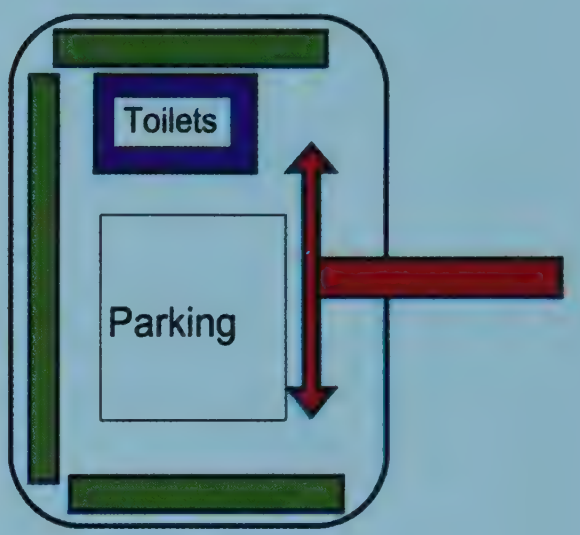


Fig. 13.1E Small-sized Amenity

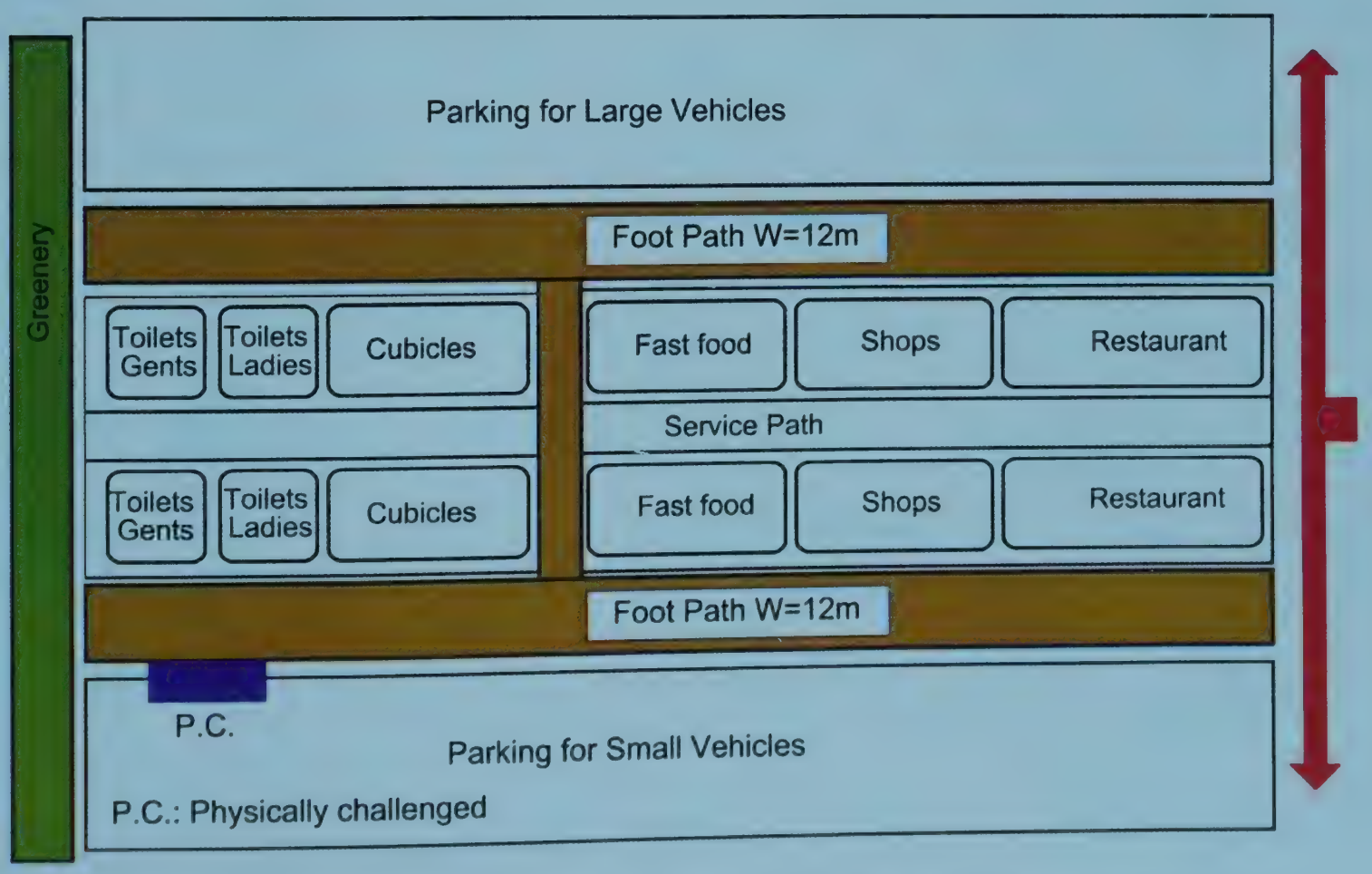


Fig. 13.1F Typical Layout of Service Areas

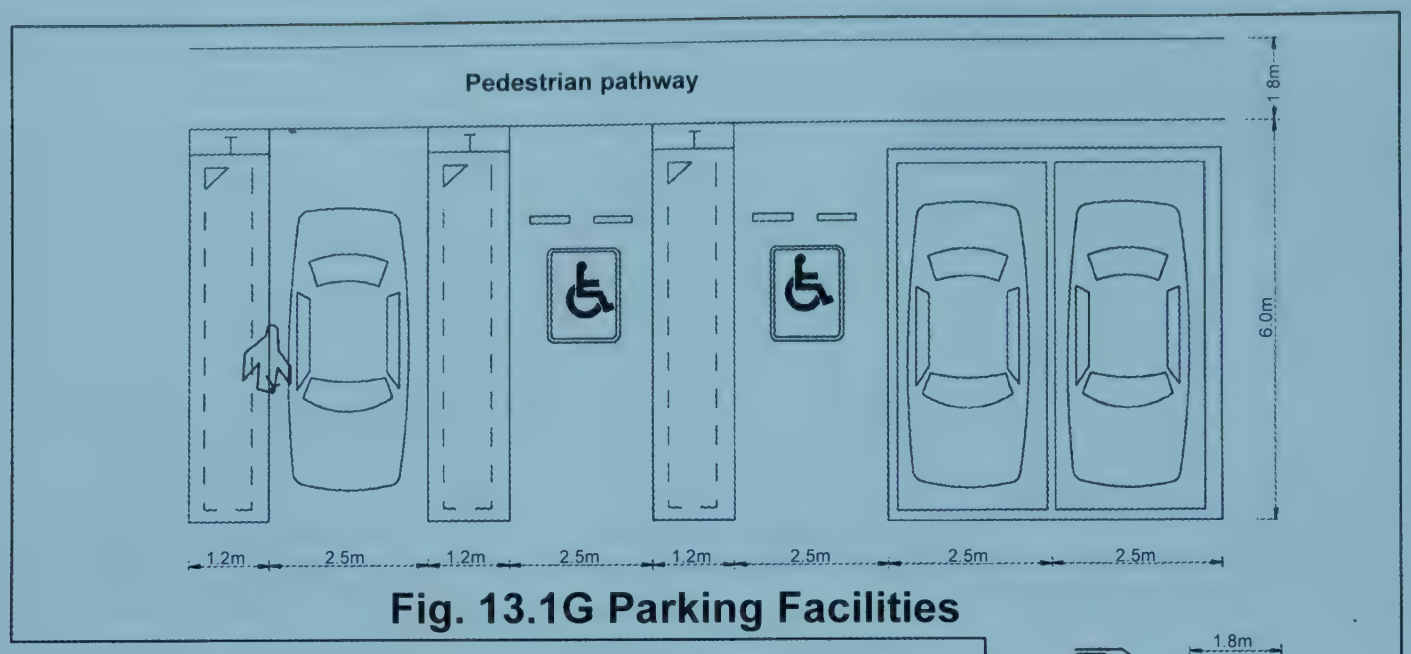


Fig. 13.1G Parking Facilities

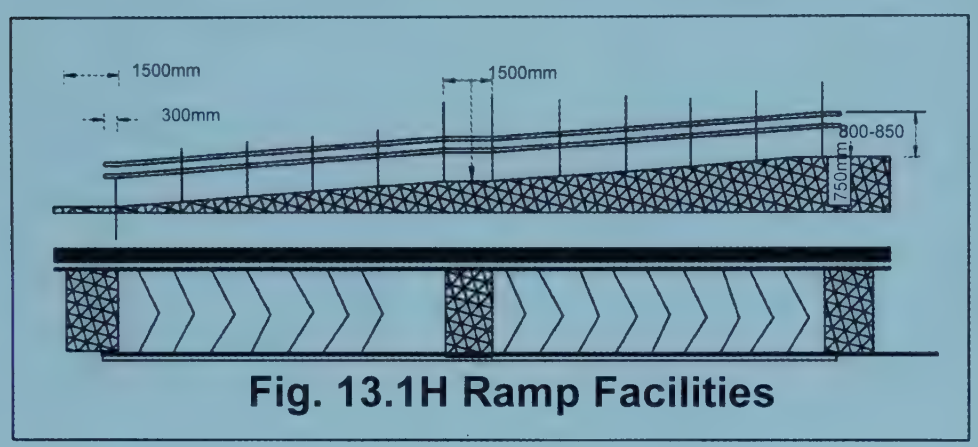


Fig. 13.1H Ramp Facilities

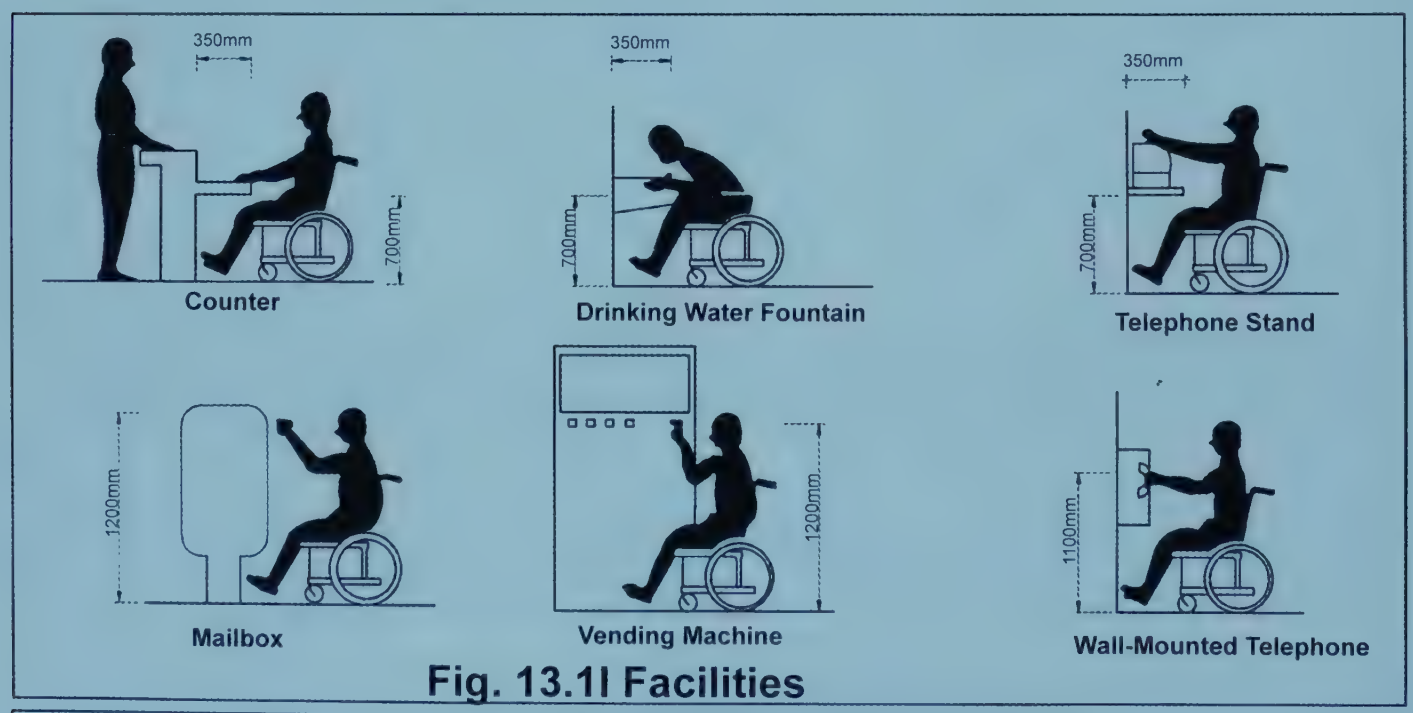


Fig. 13.1I Facilities

Fig. 13.1J Signage Facilities

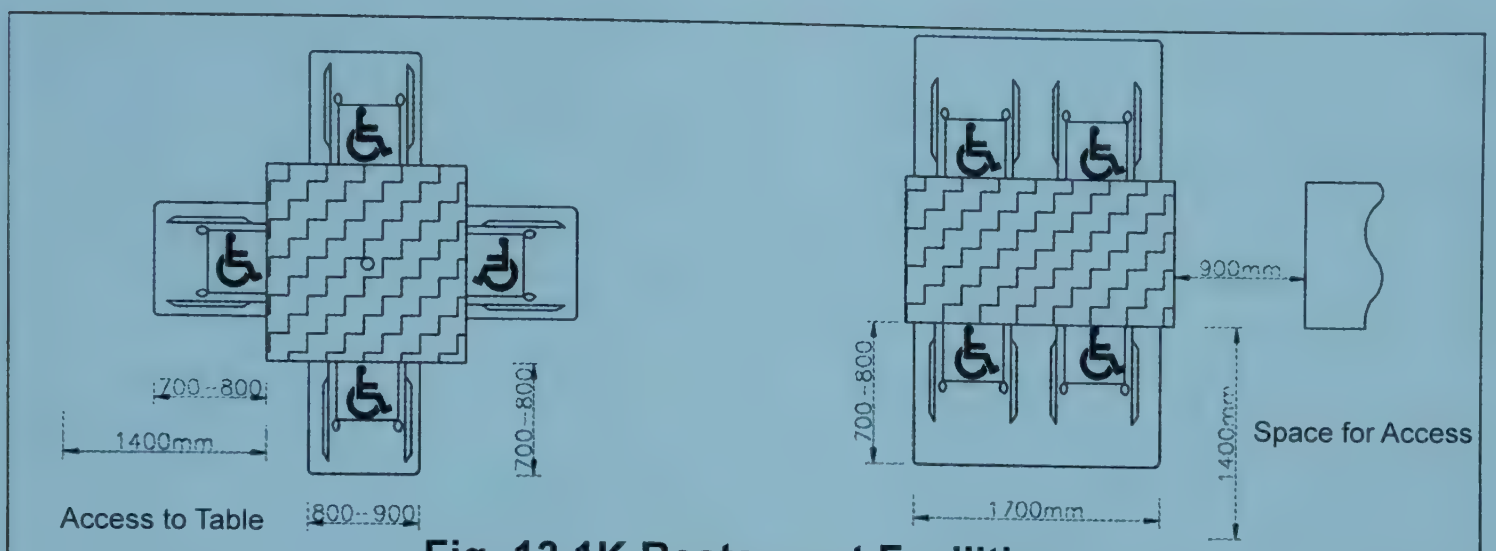


Fig. 13.1K Restaurant Facilities

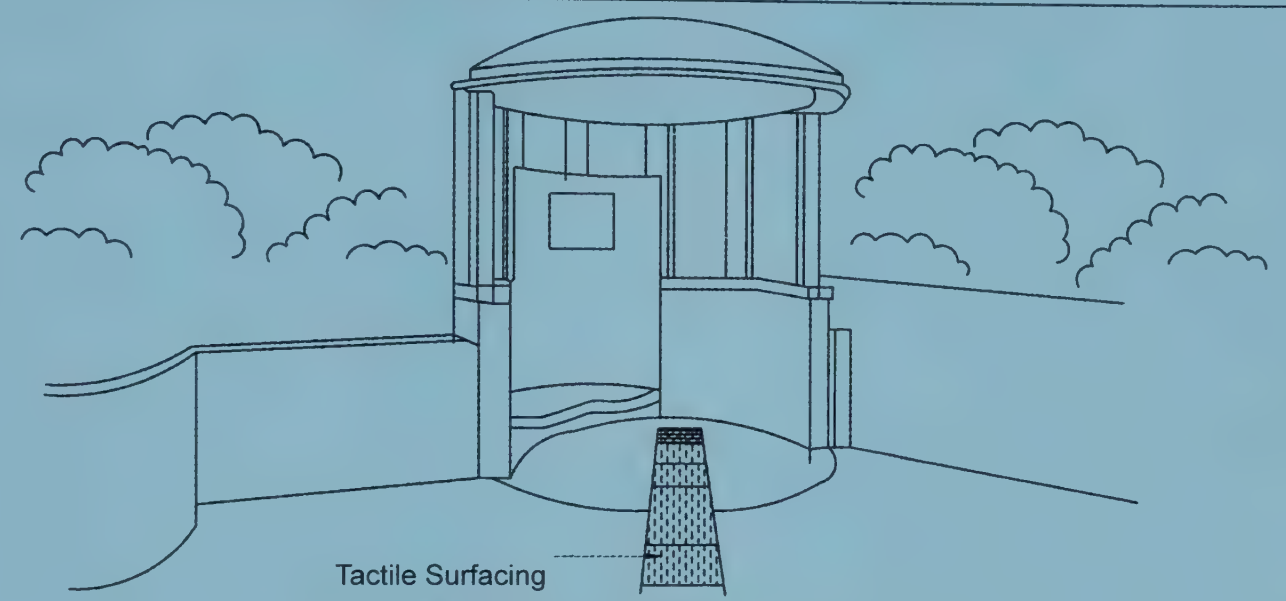


Fig. 13.1L To Restaurant or Toilet

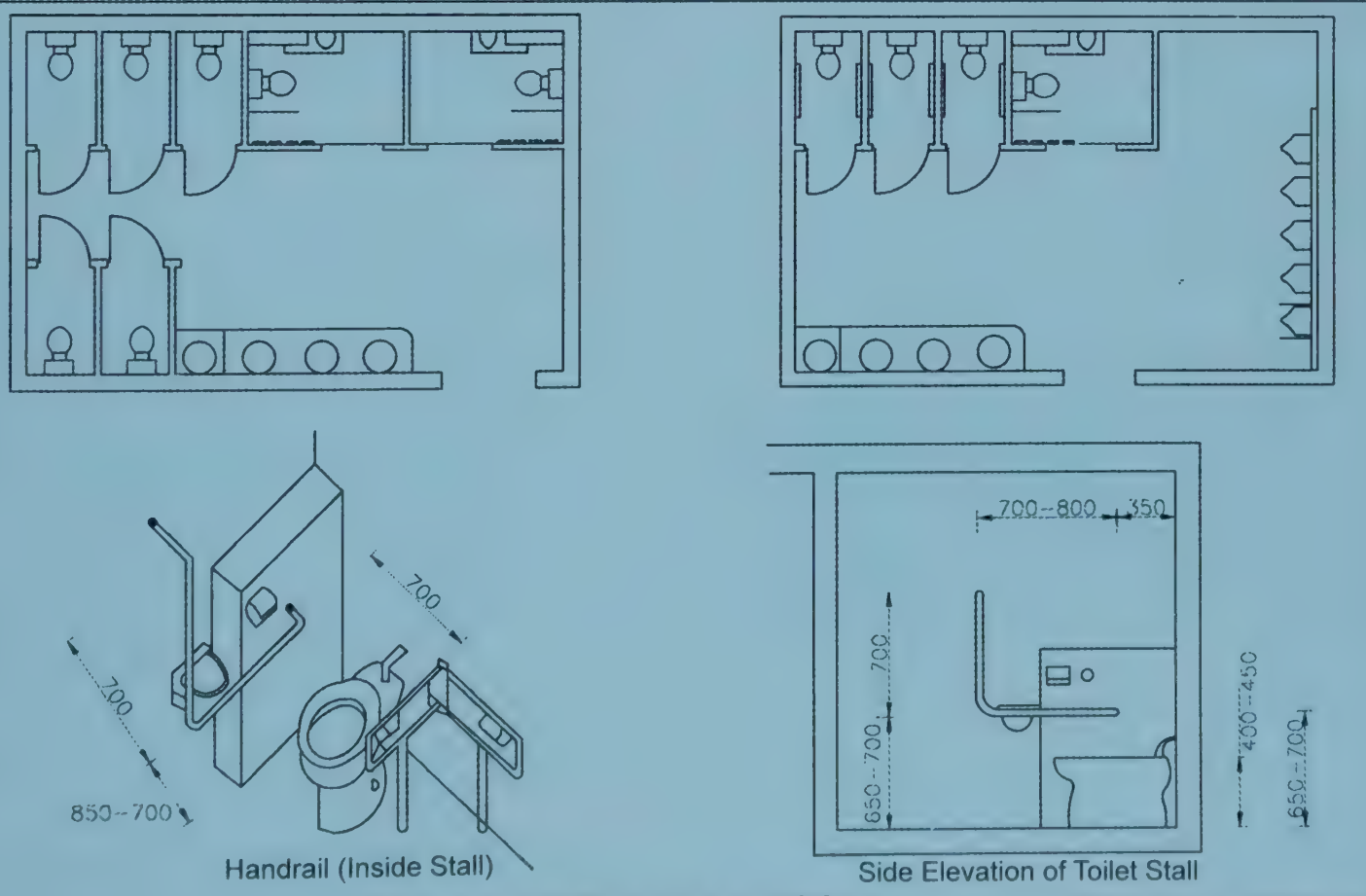


Fig. 13.1M Toilet Facilities (Dimension in millimeters)

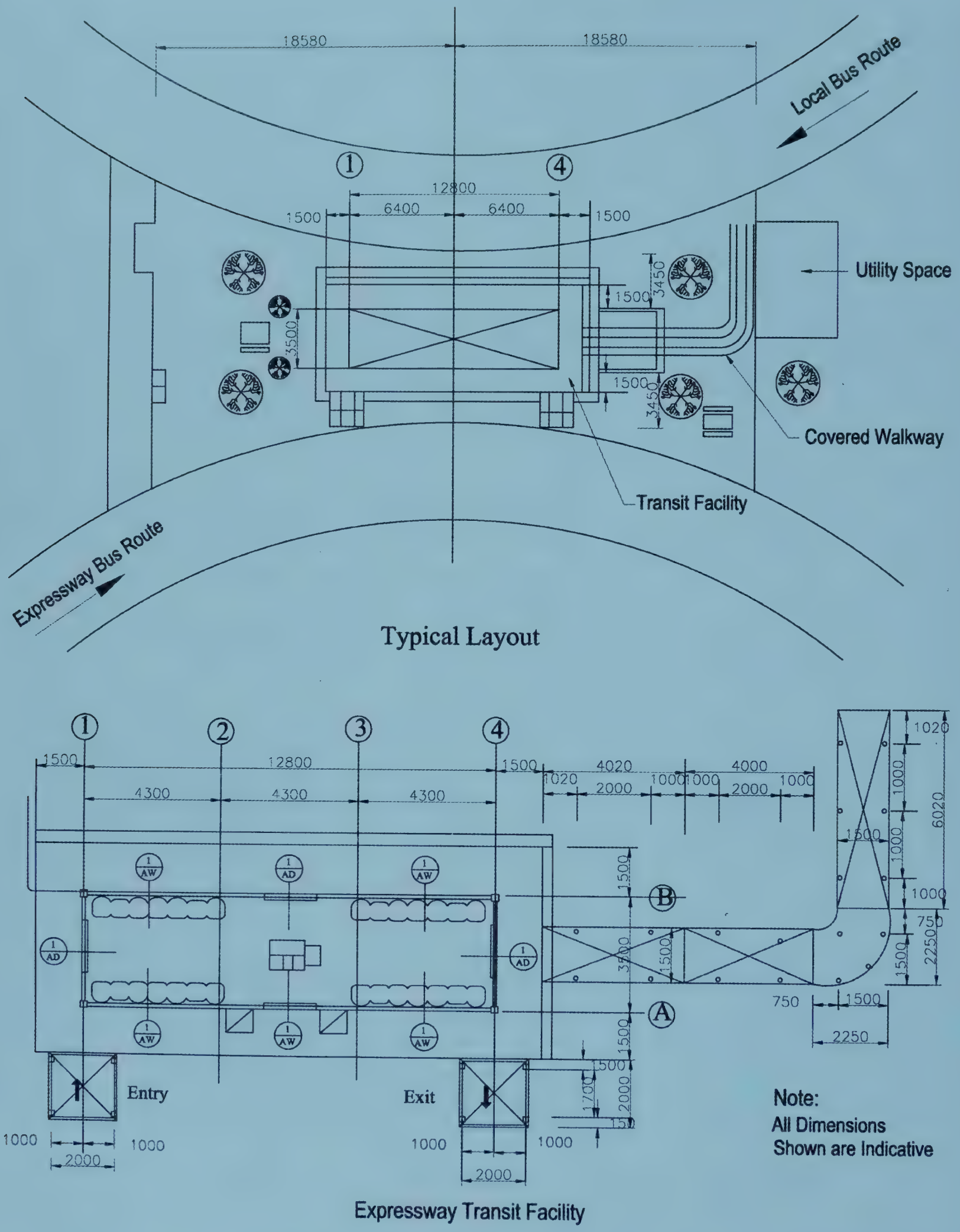


Fig. 13.2 Typical Functional Arrangement of Expressway Bus Route and Local Bus Route at Bus Stop

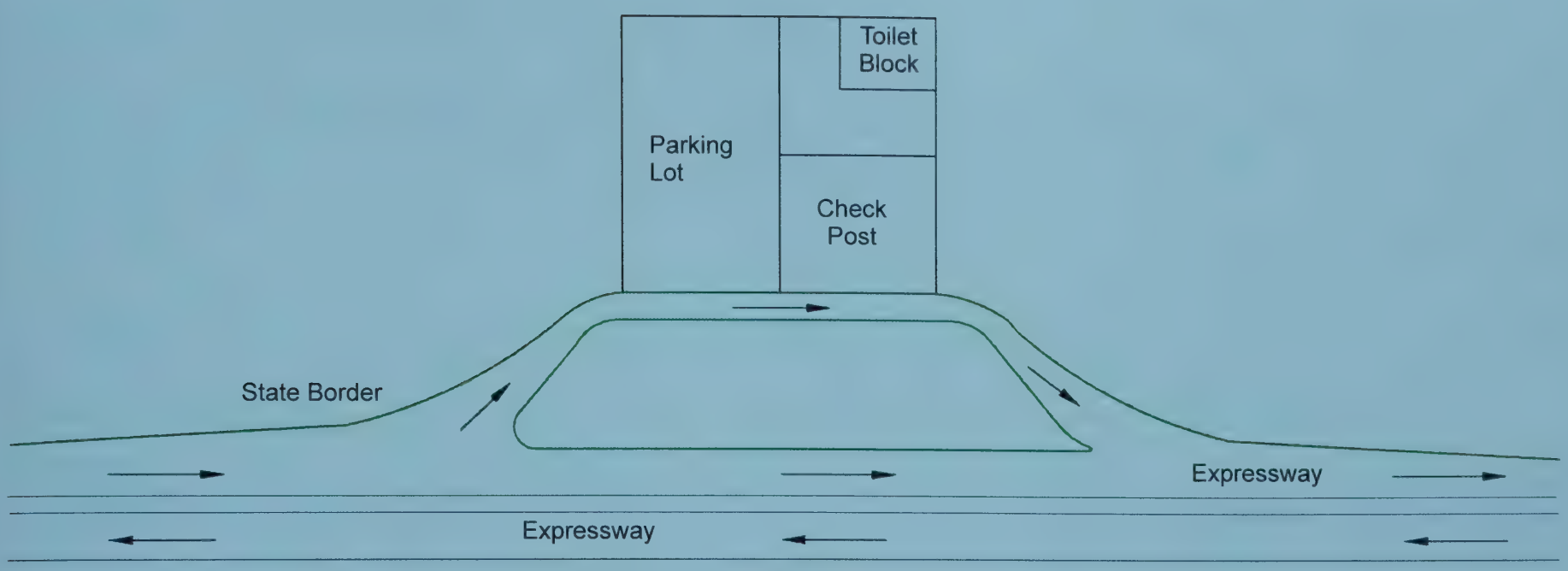


Fig. 13.3 Typical Layout of State Border & Entry Check Post

SECTION 14

ENVIRONMENTAL AND SOCIAL ASPECTS, LANDSCAPING AND TREE PLANTATION

14.1 Context

Expressway projects are likely to be associated with some adverse environment impacts during construction, maintenance and operation stages. Significant impacts during construction relate to clearing, grading or road bed construction; loss of vegetative cover; foreclosure of land uses; property severance at community/individual levels; changes in natural drainage patterns; changes in ground water table, landslides, erosion, streams, ponds and lake sedimentation, degradation of cultural sites, interference with movements of wild life, livestock and local residents. Many of these impacts can arise not only at construction sites but also at quarries, borrow pits and material storage areas serving the Project Expressway. In addition, impacts can occur due to air and ground pollution from construction plants; dust from construction vehicle movements, noise from construction equipment and blasting, use of pesticides, fuel and oil spills, trash and garbage etc.

14.2 Environmental Management Plan

Many of the direct adverse impacts can be avoided / mitigated at the design stage. Accordingly while the Authority will seek the Environmental clearance for the Project Expressway from the relevant Ministries, Departments; the Concessionaire shall be responsible for implementation of Environmental Management Plan and action plan for undertaking possible mitigation measures in accordance with extant guidelines for highway projects of the Ministry of Environment and Forests (MOEF) and Wildlife Department of the Government of India.

The Authority shall make available to the Concessionaire, the list of conditions and directions stipulated by the MOEF at the time of giving their clearance for the Project Expressway and it shall be the responsibility of the Concessionaire to incorporate the same in its Environmental Management Plan referred to above.

14.3 Landscaping and Tree Plantation

14.3.1 *General*

The Concessionaire shall plant trees and shrubs of required number and type at the appropriate locations within the Right of Way and in the land earmarked by the Authority for afforestation keeping in view the IRC Guidelines on Landscaping and Tree Plantation. The Authority will specify the number of trees which are required to be planted by the Concessionaire as compensatory afforestation or otherwise in **Schedule C** of the Concession Agreement. The Concessionaire shall also maintain the trees and shrubs in good condition during the Concession Period as per the maintenance schedule. Plantation shall be within the fenced area of the Right of Way of the Expressway.

14.3.2 *Design considerations in various locations*

a) Set-Back Distance of Trees and Other Plantation

Trees on the roadside shall be sufficiently away from the roadway so that they are not a hazard to road traffic or restrict the visibility. Most vulnerable locations in this regard are the inside of curves, medians, entry/exit ramps and cut slopes. Trees shall be placed at a minimum distance of 14 m from the centre line of the left side paved shoulder to provide recovery area for the vehicle that runs off the road.

b) Plantation in Medians

In the sections of the Project Expressway where median width is more than 3 m, shrubs shall be planted and maintained to cut off headlight glare from traffic in the opposite direction. Flowering plants and shrubs are eminently suited for the purpose. These shall be planted either in continuous rows or in the form of baffles. The height of shrubs shall be maintained at 1.5 m to cut off the effect of traffic lights coming from the opposite direction. Number of rows shall be decided as per width of median in a space of 1.5m.

The shape of shrubs and plants shall be suitably regulated so that there is no overgrowth either vertically or horizontally beyond the edge of the paved median.

c) Spacing of Avenue Trees

The spacing of avenue trees will depend on the type and growth characteristics of trees, requirement of maintenance, penetration of distant views, etc. Spacing of avenue trees shall be as per provision of **IRC:SP:21**.

The following guidelines shall be kept in view while selecting the species of trees to be planted:

i) Trees shall be selected with due regard to soil, rainfall, temperature and water level.

ii) Trees which become very wide shall be avoided as their maintenance would cause interference with traffic flow.

iii) The species must be capable of developing a straight and clean bole up to a height of 2.5 to 3.5 m from the ground level.

iv) The selected trees shall, preferably, be fast growing and wind-firm. These shall not be thorny or drop too many leaves.

v) The trees shall be deep rooted, as shallow roots injure pavements.

vi) In urban areas, the species selected shall be of less spreading type, so that these do not interfere with overhead services, clear views of signs/ signals, and efficiency of roadway lighting.

14.4 Landscape Treatment

A suitable landscape treatment with provision of fountains and coloured lighting along with drip irrigation, sprinkless etc. so as to enhance the overall aesthetics duly designed by a qualified and experienced landscaping architect, shall be provided at grade separators, elevated sections, viaducts, traffic islands, toll plazas, bus bays, truck lay byes, rest areas, O&M centre, etc. The locations where landscape treatment is to be given shall be specified in **Schedule C** of the Concession Agreement. The landscape treatment shall also be provided for special areas as given in **IRC:SP:21 (Para 8)**.

14.5 Report to be Submitted

The Concessionaire shall submit scheme for Environmental Management Plan (EMP) and for plantation and maintenance of plants and trees to the Independent Engineer for review and comments, if any.

SECTION 15

LIGHTING

15.1 General

i) The Concessionaire shall provide lighting at locations of the Project Expressway specified in **Schedule C** of the Concession Agreement, using appropriate system and source of electric power as per the requirements of this Section.

ii) The Concessionaire shall make suitable arrangements for procuring power supply to ensure uninterrupted lighting during night and when visibility is low, including provision of Diesel Generator sets as standby arrangements.

iii) The Concessionaire shall bear all costs of procurement, installation, running and operation cost of all lighting, including cost of energy consumption specified in this Section.

15.2 Specifications

i) Unless stated otherwise elsewhere in this Manual, the minimum level of illumination on the stretches of the Project Expressway including Toll Plazas, truck lay-byes, interchanges etc. shall be as given in **Table 15.1**.

Table 15.1 Minimum Level of illumination

Category	Minimum Average level	U0	U1	T1
Expressways	45 lux	0.4	0.7	15%

Where,

U0: overall uniformity ratio

U1: uniformity along the axis of the road

T1: maximum glare

ii) The layout of the lighting system together with type of luminaries for different locations shall be prepared by the Concessionaire in such a manner that the minimum illumination level prescribed in para 15.2(i) is achieved and shall be submitted to the Independent Engineer for review and comments, if any, for compliance by the Concessionaire.

iii) Overhead electrical power and telecommunication lines erected within the ROW by the Concessionaire shall be provided with adequate clearance so that safe use of the Expressway is not affected.

iv) Vertical and horizontal clearances for electrical installations shall conform to **IRC:32**.

v) All the fixtures, wires/cables, lights shall conform to relevant BIS specifications as a minimum. The Concessionaire with the prior review and comments of the Independent Engineer can use fixtures with better specifications.

15.3 Lighting Standards

The overall quality of an installation for lighting has several components:

i) Average luminance level: This is all-important, as it not only impinges on the safety benefits but also largely determines the power requirements and hence the running costs. In simpler design processes, and for checking the performance of an installation, this translates into average illuminance level.

ii) Overall uniformity of luminance, or illuminance, both across and along the roadway. Defined as the minimum divided by the average, and designated at U0.

iii) Uniformity of luminance, or illuminance, along the axis of the road, usually an axis which coincides with a typical driver's eye position. Defined as the ratio of the minimum to the maximum, and designated U1.

iv) Glare: As glare has the effect of reducing contrast, a luminary's "glare performance", or optical control, can be expressed in terms of the increase in background luminance necessary to compensate (threshold increment, T1). The lower this figure the better. These percentages are determined by the amount of light the luminaries project near the horizontal. This light also causes problems of sky-glow.

v) Guidance: Whilst glare must be kept under control, a small amount of direct light from the luminaries gives a useful sense of the "run" of the road ahead, and can forewarn the approach of junctions or roundabouts.

15.4 Locations Where Lighting is to be Provided

Unless specified otherwise in **Schedule C** of the Concession Agreement and elsewhere in this Manual, the Concessionaire shall provide lighting at the following locations of the Project Expressway ensuring 24×7 supply at all locations.

15.4.1 *Continuous expressway lighting*

i) Continuous expressway lighting is considered to be warranted on those sections where three or more successive interchanges and cross roads are located with an average spacing of 2.5 km or less, and adjacent areas outside the right-of-way are urban in character.

ii) Continuous expressway lighting shall be provided where for a length of 3.0 km or more, the expressway passes near an urban area in which one or more of the following conditions exist:

a) Local traffic operates on a complete street grid having some form of street lighting, parts of which are visible from the expressway.

b) The expressway passes near a series of developments such as residential, commercial, industrial and civic areas, schools, colleges, parks, terminals, wayside amenities etc., which includes roads, streets and parking areas, yards, etc. that are lighted.

iii) In rural areas each location must be individually evaluated as to its need for illumination.

15.4.2 *Interchange lighting*

Complete interchange lighting shall be provided on all the interchanges.

15.4.3 *Bridge structures and underpasses lighting*

Lighting shall be provided on entry/exit ramps and grade separated structure (underpass, overpass flyovers etc.,) including approaches and inside of under passes.

15.4.4 *Special situations Tunnels*

Tunnels require the use of lighting or equivalent means to provide adequate roadway and tunnel user visibility necessary for safe and efficient traffic operations. The tunnel lighting shall be designed as per MoRTH Guidelines for Expressways, **Section 13.5 "Tunnel Lighting"**.

Toll Plaza Areas

The lighting in and around Toll Plaza, toll booths, office building, on the approach road, etc. shall be as per **Section 12 "Toll Plazas"** of this Manual.

Wayside Amenities

All Wayside Amenities offering facilities should be lighted, including the entrance and exit, the interior roadways, parking areas, and activity areas. Wayside Amenities include Rest Areas, Truck/Bus laybys, and Pick-up bus Stops. The lighting of Wayside Amenities shall be as per **Section 13 "Project Facilities"** of this Manual.

Other Specialized Areas

Lighting of other specialized areas should be considered with respect to the needs of the users as well as the requirements of others interacting with the users. These other specialized areas include truck weighing stations, inspections and enforcement areas, park-and-ride lots, toll plazas, and escape ramps.

15.5 Report to be Submitted

The Concessionaire shall submit report containing the proposal for provision of Lighting on the Project Expressway to the Independent Engineer for review and comments, if any.

SECTION 16

OPERATIONS AND MAINTENANCE

16.1 Operations and Maintenance Requirements

16.1.1 The Concessionaire is responsible to operate and maintain the project Expressway in accordance with scope defined in **Schedule K** of the Concession Agreement which shall also be developed in line with the tolerance criteria specified in this section and the Concessionaire shall always operate and maintain the project Expressway such that;

a) Lane availability at the end of each year of the Concession will be minimum of 99% on cumulative basis.

b) Adequate safety measures are taken up on the construction zone during the O&M period

c) Delay to users of the Project Expressway and of adjoining roads or facilities is minimised.

d) Risk of adverse effects on the environment and on the amenity enjoyed by the owners and occupiers of property and/or land adjacent to the Project Expressway, adjoining roads and facilities is minimised.

e) Accidents and emergencies on the Project Expressway and facilities thereon are responded to as quickly as possible and their adverse effects minimised.

f) Risk of disturbance or damage or destruction to property of third party is minimised.

g) Members of the public are treated with due courtesy and consideration.

h) Users are given adequate information and forewarning of any event on or any other matter affecting the Project Expressway which will enable them to minimise any adverse consequences on them of that event or matter.

i) Members of the public and others are given adequate opportunity to bring to the attention of the Concessionaire any matters affecting its ability to meet the O&M Requirements.

j) Traffic data and data relating to the operation and maintenance of the Project Expressway and its facilities and events on the Project Expressway are collected and disseminated such that the Ministry or NHAI and other persons or bodies with statutory duties or functions in relation to the Project Expressway or adjoining roads are able to perform those duties and functions efficiently.

k) The project facilities shall be operated and maintained in order to fulfill the requirements set forth in the Concession Agreement and /or the relevant Schedule.

16.1.2 *The scope for Operation and Maintenance includes but not limited to following*:

a) Improvement – includes improvement of the existing assets as per requirement of the Agreement.

b) Road Maintenance – includes routine maintenance, preventive maintenance, periodic maintenance, disaster maintenance, exigencies and inspections.

c) Traffic Management – includes enforcement of regulations together with the relevant authorities. This also includes hazard response, information gathering and dissemination, Road patrols and ATMS surveillance.

d) Safety – includes accident prevention, after care, user education, enforcement, data collection and analysis.

e) Facility management – includes periodic inspections, routine maintenance, rehabilitation and expansion planning.

f) Road property management – includes management of access, encroachment and ribbon development.

g) General responsibilities – includes budgeting, compliance with legal and accounting requirements, and public relations.

h) Maintaining public relations unit to interface with and attend to suggestions from users of the highway, the media, Govt. agencies and other external agencies.

16.1.3 *Traffic Management and Lane Closure*

Traffic Management during Operation and Maintenance of the Project Highway is an important activity the Concessionaire has to attend to ensure safety of the road users as well as the maintenance workers simultaneously throughout the Concession Period. It is usual activity to carry out various types of maintenance works at different stages and at different periods as per site requirement. Also, it is a vital activity during unforeseen and/or emergency situations arising on account of natural causes or accidents or administrative reasons.

16.1.4 Traffic Management is required during planned scheduled like Routine and Periodic maintenance activities. However, traffic management will also be called for during unscheduled activities such as

i) Emergency situation arising on account of

a) Force Majeure

b) Accident/incident on the Project Highway

ii) Special repairs required on account of failure of an element of the Project Highway; and

iii) Default of the Concessionaire with respect to an operational activity on the Project Highway

16.1.5 The basic principles to be followed for traffic management and lane closure in this Project Highway shall be as follows:

a) Work programme schedule shall be prepared in a manner that diversion roads for the main traffic are minimized. Two-lanes of carriageway shall be available to the maximum extent possible.

b) Measures shall be taken such that the traffic is guided from a closed lane onto the operating lane without any conflict with the traffic from the opposite direction.

c) The activity of renewal of pavement surface and/or strengthening of the pavement structure shall not be taken up in a continuous length of more than 2 Km at a time to avoid long detour of the traffic.

d) The traffic diversion road where provided shall be appropriately designed for the traffic plying on the main carriageway. It shall also be properly maintained during its operation period.

e) During traffic detour involving traffic diversion, adequate safety measures shall be followed.

f) Proper and adequate information about the maintenance activity shall be notified to the road users on Variable Message Sign Boards (VMS) well before approaching the work site. Traffic Management and Diversion arrangement at the work site shall be as per **IRC:SP:55** or subsequent updates thereof. In addition to this, Robot Flagman and other advanced traffic diversion devices shall be used for diversion arrangement.

16.1.6 Traffic Management Plan and programme for a planned scheduled construction and/or maintenance activity shall be prepared in advance of that activity keeping 16.1.5 above in view and be approved by the Independent Consultant/NHAI as the case may be.

16.1.7 In case of unscheduled activities, described in **Para 16.1.3** above, an emergency traffic management for the affected reach of the highway shall be prepared and implemented in line with the guidelines set forth Standards and Specifications in **Schedule C**. This emergency traffic management plan shall take into account the various requirements spelt out in the Concession Agreement as well as in this schedule.

16.1.8 Traffic Management and Lane Closures Requirements during Emergency situations arising on the Project Highway needing Traffic Management are detailed below:

a) This stage could arise any time and shall have to be addressed based on its own merits. The extent of traffic management shall be assessed as per the site requirement and situation.

b) The nature of emergency requirement will determine the type and extent of the traffic diversion.

c) Traffic Management Plan in emergency shall be prepared and implemented as per Standards and Specifications set forth in **Schedule C**.

16.2 Inspection Schedule and Tolerance Criteria

16.2.1 The Concessionaire shall maintain various assets under respective tolerance limits specified in Schedule L or as per this manual by conducting regular inspection in-accordance of provisions of the Concession Agreement shall plan/programme inspections of various assets that form part of the Project Expressway. The broad classification of the inspections are as follows:

i) Routine Inspection

Routine Visual Inspections are to be carried out by highway/bridge maintenance engineers having knowledge of highway/road structures. The purpose of visual inspection is to report the obstacles to traffic, defects and deficiencies of pavement/ structure, missing or damages to safety barrier (crash barriers) and traffic signs installed or erected on highway. Such inspections should be done daily. The visual inspection may be carried out by visual assessment with careful observation of the specific object/item of the Project Facilities for identification and for quantification of the deficiencies or damages of the Project Facilities. Geotagging Cameras and Distance Measuring Devices shall be used to update base asset performance parameters on daily basis. If timely inspection and reporting of these safety related deficiencies are not done, they could lead to accidents or severe maintenance problems.

ii) Close Inspection

Close inspections for assessment of defects/deficiencies of Project Highway shall be periodic in nature and would require detailed examination of all elements of the Project Highway. Close inspection may be visual or may involve investigations to be carried out using instruments. The frequency of close inspections would depend upon the nature of the elements of Project Highway. This inspection is to be carried out by the Highway/Bridge Engineer having good knowledge of Highway with theoretical background to analyse the nature, and extent of defects/deficiencies, suggest suitable remedial measures to rectify/remedy them and quantify repair work.

iii) Thorough Inspection

A thorough inspection is comprehensive and detailed assessment of defects/

deficiencies of the Project Highway with the aid of standard equipment and non-destructive testing. Such an inspection is to be carried out on the basis of comprehensive checklist of items related to the materials, condition of element of Project Highway. A checklist is to be prepared well in advance of inspection. The thorough inspection should be undertaken during the most critical weather condition. Thorough inspection carried out will offer the most critical evaluation of the performance of the Project Highway elements.

Besides being a qualified Highway/Bridge Engineer, the inspection Team Leader must be familiar with design and construction features of the Highway /Bridges to be inspected so that the condition can be properly and accurately assessed for a meaningful report and quantification of repair works. The competence of team leader to recognize any structural distress/deficiencies and assess its seriousness with complete recommendation for appropriate repairs are important pre-requisites for entrusting this assignment to him.

16.2.2 Various tolerance criteria for different assets of project Expressway are mentioned in **Table 1 to 4**.

Table 1: Maintenance Criteria of Pavements

Asset Type	Performance Parameter	Level of Service		Frequency of Inspection	Tools/ Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specification
		Desirable	Acceptable					
Flexible Pavement	Potholes	Nil	<5 sqm in area and 10mm in depth	Daily	Length Measurement unit like Scale, Tape, Odometer etc.	IRC:82-2015 and Distress identification manual for Long Term Pavement Performance Program, FHWA 2003 (http://www.tfhrc.com/pavement/lttp/reports/03031/)	24-48 hours	MoRT&H Specification 3004.2
	Cracking	Nil	<10% for any 50m section and/ or 0.5 sq. m at any location	Daily			7-15 days	MoRT&H Specification 3004.3

Asset Type	Performance Parameter	Level of Service		Frequency of Inspection	Tools/ Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specification
		Desirable	Acceptable					
	Corrugation and Shoving	Nil	<1 sq.m at any particular section and depth <10m	Daily	Length Measurement unit like Scale, Tape, Odometer etc.		2-7 days	IRC:82-2015
	Bleeding	Nil	<1% for any 50m section and/or 0.25 sq.m at any location	Daily	Length Measurement unit like Scale, Tape, Odometer etc.	IRC:82-2015 and Distress identification manual for Long Term Pavement Performance Program, FHWA 2003 (http://www.tfhrc.com/pavement/lttp/reports/03031/)	3-7 days	MoRT&H Specification 3004.4
	Ravelling/ Stripping	Nil	<3% for any 50m section and/ or 1sq.m at any location	Daily			7-15 days	IRC: 82-2015 read with IRC: SP: 81
	Edge Deformation/ Breaking	Nil	<1m for any 100m section and/or width<0.1m at any location	Daily			7-15 days	IRC:82:2015

Asset Type	Performance Parameter	Level of Service		Frequency of Inspection	Tools/ Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specification
		Desirable	Acceptable					
	Roughness IRI, BI	2.8, 2000mm/ km	4.0, 3000mm/km	Bi-Annually	Class 1 Profilo-meter	Class 1 Pro-filometer: ASTM E950(98):2004-Standard Test Method for measur-ing Longitudinal Profile of travelling surfaces with accel-erometer established inertial profiling reference, ASTM E 1656-94:2000-Stand-ard guide for classi-fication of automatic pavement condition survey equipment and Network Survey Vehicle	180 days	IRC:82:2015
	Skid Number	60SN	50SN	Bi-Annually			180 days	MoRT&H Specification 3004.2
	Rutting	<10mm for any 50m section and/or length of section <5m	<10mm for any 50m section and/ or, length of section <10m	Bi-Annually			15-30 days	MoRT&H Specification 3004.2
	Pavement Condition Index	>85	>70	Bi-Annually			180 days	IRC:82:2015
	Other pavement distress			Bi-Annually			2-7 days	IRC:82:2015
	Deflection/ Remaining Life			Annually	Falling Weight Deflectometer	IRC:115-2014	180 days	IRC: 115-2014

Asset Type	Performance Parameter	Level of Service		Frequency of Inspection	Tools/ Equipment	Standards and References for Inspection and Data Analysis	Time limit for Rectification/ Repair	Maintenance Specification
		Desirable	Acceptable					
Rigid Pavement	Roughness IRI, BI	<3.0, 2200mm/km	4.0, 3000mm/km	Bi-Annually	Class1 Profilometer	ASTM E950(98):2004 and ASTM E1656-94:2000		
	Skid	>65 BPN	>45 BPN	Bi-Annually	British Pendulum Tester	IRC: SP:83-2008	180 days	IRC: SP:83-2018
Embankment/Slope	Edge drop at shoulders	Nil	40mm	Daily	Length measurement unit like Scale, Tape, Odometer etc.	Relevant IRC Standard	180 days	IRC: SP:83-2018
	Slope of Camber/Cross fall	Nil	<2% variation in prescribed slope of camber/ cross fall	Daily			7-15 days	MoRT&H Specification 408.4
	Embankment Slopes	Nil	<15% variation in prescribed slide slope	Daily				
	Embankment Protection	Nil		Daily				
	Rain cuts/gullies in slope	Nil		Daily	NA			

Table 2: Maintenance Criteria of Rigid Pavement

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
1	Single discrete cracks not intersecting with any joint	w= width of crack, L=length of crack, d= depth of crack, D=depth of slab	0	Nil, not discernible	No action	Not applicable
			1	w<0.2mm, hair cracks		
			2	w= 0.2-0.5mm, discernible from slow-moving car	Seal without delay	Seal, and stitch if L>1m
			3	w= 0.5-1.5mm, discernible from fast-moving car		
			4	w= 1.5-3.0mm	Seal, and stitch if L>1m	Staple or dowel bar retrofit, FDR for affected portion
			5	w> 3mm		
2	Single transverse (or diagonal) cracking intersecting with one or more joints	w= width of crack, L=length of crack, d= depth of crack, D=depth of slab	0	Nil, not discernible	No action	
			1	w<0.2mm, hair cracks	Route and seal with epoxy	Staple or dowel bar retrofit
			2	w= 0.2-0.5mm, discernible from slow-moving car		
			3	w= 0.5-3mm, discernible from fast-moving car	Route, seal, and stitch, if L>1m	
			4	w= 3.0-6.0mm	Dowel bar retrofit	Full depth repair dismantle and reconstruct affected
			5	w> 6mm, usually associated with spalling, and/or slab rocking under traffic	Not applicable, as it may be full depth	

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
3	Single longitudinal crack intersecting with one or more joints	w= width of crack, L=length of crack, d= depth of crack, D=depth of slab	0	Nil, not discernible	No action	
			1	w<0.5mm, discernible from slow moving vehicle	Seal with epoxy, if L>1m	Staple or dowel bar retrofit
			2	w= 0.5-3.0mm, discernible from fast-moving car	Route, seal and stitch, if L>1m	
			3	w= 3.0-6.0mm	Staple, if L>1m	Partial depth repair with stapling
			4	w=6.0-12.0mm, usually associated with spalling	Not applicable, as it may be full depth	
			5	w>12mm, usually associated with spalling, and/or slab rocking under traffic		Full depth repair dismantle and reconstruct affected portion
4	Multiple cracks intersecting with one or more joints or cracks	w=width of crack	0	Nil, not discernible	No action	
			1	w<0.2mm, hair cracks	Seal, and stitch if L>1m	
			2	w= 0.2-0.5mm, discernible from slow-moving car		
			3	w= 0.5-3.0mm, discernible from fast-moving car	Full depth repair	Dismantle, reinstate sub-base, reconstruct whole slab
			4	w=3.0-6.0mm, panel broken into 2-3 pieces		
			5	w>6.0mm and/or panel broken into more than 4 pieces		

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
5	Corner breaks	w= width of crack, L=length of crack	0	Nil, not discernible	No action	
			1	w<0.5mm, only 1 corner broken	Seal with low viscosity epoxy to secure broken parts	Seal with epoxy
			2	w<1.5mm and L<0.6m, only one corner broken		
			3	w<1.5mm and L<0.6m, two corners broken	Partial depth (refer Figure 8.3 of IRC: SP:83-2008)	Full depth repair
			4	w>1.5mm and L>0.6m or three corners broken		
			5	Three or four corners broken		Reinstate sub-base, and reconstruct the slab
6	Punch Out (Applicable to CRCP only)	w=width of crack, L=length (m/m2)	0	Nil, not discernible		No action
			1	w<0.5mm, L<3m/m2	Not applicable, as it may be full depth	Seal with low viscosity epoxy to secure broken parts
			2	Either w>0.5mm or L<3m/m2		
			3	w>1.5mm and L<3m/m2		
			4	w>3mm, L<3m/m2 and deformation		Full depth repair-cut out and replace damaged area taking care not to damage reinforcement
			5	w>3mm, L>3m/m2 and deformation		

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
Surface Defects						
7	Ravelling or honeycomb type surface	r=area damaged surface/total surface or slab (%), h=maximum depth of damage	0	Nil, not discernible	Short term	Long term
					No action	Not applicable
			1	r<2%	Local repair of areas damaged and liable to be damaged	
			2	r= 2-10%		
			3	r=10-25%	Bonded inlay, 2 or 3 slabs if affecting	
			4	r=25-50%		
			5	r>50% and h>25mm	Reconstruct slabs, 4 or more slab if affecting	
8	Scaling	r=area damaged surface/total surface or slab (%), h=maximum depth of damage	0	Nil, not discernible	Short term	Long term
					No action	Not applicable
			1	r<2%	Local repair of areas damaged and liable to be damaged	
			2	r= 2-10%		
			3	r=10-20%	Bonded Inlay	
			4	r=20-30%		
			5	r>30% and h>25mm	Reconstruct slabs	

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
9	Polished surface/ Glazing	t=texture depth, sand patch test	0	Nil, not discernible	Short term	Long term
			1	t> 1.0mm	No action	Not applicable
			2	t =1.0-0.6mm	Monitor rate of deterioration	
			3	t =0.6-0.3mm		
			4	t =0.3-0.1mm		
			5	t< 0.1mm	Diamond grinding if affecting 50% or more slabs in a continuous stretch of minimum 5km	
10	Pop out (small hole)	n=number/m^2, d= diameter, h=maximum depth	0	d<50mm, h<25mm, n< 1 per $5m^2$	Short term	Long term
					No action	Not applicable
			1	d=50-100mm, h<50mm, n<1 per $5m^2$	Partial depth repair 65mm deep	
			2	d=50-100mm, h>50mm, n<1 per $5m^2$		
			3	d=100-300mm, h<100mm, n<1 per $5m^2$	Partial depth repair 110mm i.e. 10mm more than the depth of the hole	
			4	d=100-300mm, h>100mm, n<1 per $5m^2$		
			5	d>300mm, h>100mm, n>1 per $5m^2$	Full depth repair	

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
Joint Defects						
11	Joint seal defects	loss or damage L=length as % total joint length	0	Difficult to discern	Short term No action	Long term Not applicable
			1	Discernible, L>25% but of little immediate consequence with regard to ingress of water or trapping incompressible material	Clean joint, inspect later	
			2	Notable, L>25% insufficient protection against ingress of water and trapping incompressible material	Clean and reapply sealant in the selected location	
			3	Severe, w>3mm negligible protection against ingress of water and trapping incompressible material	Clean, widen and reseal the joint	
12	Spalling of joints	w=width on either side of the joint, L= length of spalled portion (as % of joint length)	0	Nil, not discernible	Short term No action	Long term Not applicable
			1	w<10mm	Apply low viscosity epoxy resin/mortar in cracked portion	
			2	w= 10-20mm, L<25%		
			3	w=20-40mm, L>25%	Partial depth repair	
			4	w= 40-80mm, L>25%	30-50mm deep, h=w+20% of w	
			5	w>80mm, L>25%	50-100mm deep repair, H= w+20% of w	

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
13	Faulting (or stepping) in cracks or joints	f= difference of level	0	Not discernible, <1mm	Short term	Long term
			1	f<3mm	No action	No action
			2	f=3-6mm	Determine cause and observe, take action for diamond grinding	Replace the slab as appropriate
			3	f=6-12mm	Diamond grinding	
			4	f=12-18mm	Raise sunken slab	Replace the slab as appropriate
			5	f>18mm	Strengthen sub grade and sub-base by grouting and raising sunken slab	
14	Blow up or buckling	h= vertical displacement from normal profile	0	Nil, not discernible	Short term	Long term
			1	h<6mm	No action	Not applicable
			2	h= 6-12mm	Install signs to warn traffic	
			3	h= 12-25mm		
			4	h>25mm	Full depth repair	
			5	Shattered slabs, i.e. 4 or more pieces	Replace broken slabs	

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
15	Depression	h= negative vertical displacement from normal profile, L=length	0	Not discernible, h<5mm	Short term	Long term
			1	h= 5-15mm	No action	Not applicable
			2	h=15-30mm, Nos<20% joints	Install signs to warn traffic	
			3	h= 30-50mm		
			4	h>50mm or >20% joints	Strengthen subgrade	
			5	h>100mm	Reinstate pavement at normal level if L<50m	
16	Heave	h= positive vertical displacement from normal profile, L= length	0	Not discernible, h<5mm	Short term	Long term
					No action	Scabble
			1	h= 5-15mm	Follow up	
			2	h=15-30mm, Nos<20% joints	Install signs to warn traffic	
			3	h= 30-50mm%		
			4	h>50mm or >20% joints	Stabilise subgrade reinstate pavement at normal level if length<20m	
			5	h>100mm		

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
17	Bump	h= vertical displacement from normal profile	0	h< 4mm	Short term	Long term
					No action	
			1	h=4-7mm	Grind, in case of new construction	Construction limit for new construction
			2	h=7-15mm	Grind in case of ongoing maintenance	Replace in case of new construction
			3	h>15mm	Full depth repair	Full depth repair
18	Lane to shoulder drop off	f= difference of level	0	Nil, not discernible<3mm	Short term	Long term
					No action	
			1	f=3-10mm	Spot repair of shoulder	
			2	f=10-25mm		
			3	f=25-50mm	Fill up shoulder	
			4	f=50-75mm		For any 100m stretch reconstruct shoulder, if affecting 25% or more of stretch
			5	f>75mm		

Sl. No.	Types of distress	Measured parameter	Degree of Severity	Assessment Rating	Repair Action	
					For the case d<D/2	For the case d>D/2
Drainage						
19	Pumping	Quality of lines and water expelled through open joints and cracks nos.	0	Not discernible	No action	
			1 to 2	slight/occasional Nos<10%	repair cracks and joints without delay	Inspect and repair sub-drainage at distressed sections and upstream
			3 to 4	appreciable/frequent 10-25%	Life or jack slab	
		Nos/100m stretch	5	abundant, crack development>25%	Repair distressed pavement sections. Strengthen sub grade and sub-base. Replace slab	
20	Ponding	Ponding on slabs due to blockage of drains	0-2	No discernible problem	No action	
			3 to 4	Blockages observed in drains, but water flowing	Clean drains etc, follow up	Action required to stop water damaging foundation
			5	Ponding, accumulation of water observed	do	

Table 3: Maintenance Requirements of various Road Furniture

<table>
<tr><th>Asset Type</th><th>Performance Parameter</th><th>Level of Service (LOS)</th><th>Frequency of Measurement</th><th>Testing Method</th><th>Recommended Remedial Measures</th><th>Time limit for Rectification/ Repair</th></tr>
<tr><td>Highway</td><td>Availability of safe sight distance</td><td>As per this manual, a minimum of safe stopping sight distance shall be available throughout.
<table><tr><th>Design Speed, kmph</th><th>Desirable Minimum Sight Distance(m)</th><th>Safe stopping sight distance (m)</th></tr><tr><td>120</td><td>500</td><td>250</td></tr><tr><td>100</td><td>360</td><td>180</td></tr><tr><td>80</td><td>240</td><td>120</td></tr></table></td><td>Monthly</td><td>Manual measurement with Odometer along with video/image backup</td><td colspan="2">Removal of obstruction within 24hr, in case of sight line affected by temporary objects such as trees, temporary encroachments. In case of permanent structure or design deficiency:
• Removal of obstruction /improvement of deficiency at the earliest
• Speed restriction boards and suitable traffic calming measures such as transverse bar marking, blinkers, etc. shall be applied during the period of rectification</td></tr>
<tr><td>Pavement Marking</td><td>Wear</td><td colspan="2"><70% of marking remaining</td><td>Bi-Annually</td><td>Visual Assessment as per Annexure-F of IRC 35-2015</td><td></td><td>Cat-1 Defect - within 24 hrs, Cat-2 Defect - within 2 months</td></tr>
<tr><td></td><td>Day time visibility</td><td colspan="2">During expected service time, Cement Road-130mcd/m2/lux, Bituminous Road - 100mcd/m2/lux</td><td>Monthly</td><td>As per Annexure-D of IRC 35-2015</td><td></td><td>Cat-1 Defect - within 24 hrs, Cat-2 Defect - within 2 months</td></tr>
</table>

<table>
<tr><th>Asset Type</th><th>Performance Parameter</th><th colspan="4">Level of Service (LOS)</th><th>Frequency of Measurement</th><th>Testing Method</th><th>Recommended Remedial Measures</th><th>Time limit for Rectification/ Repair</th></tr>
<tr><td rowspan="6"></td><td rowspan="6">Night time visibility</td><td colspan="4">Initial and minimum performance for dry Retro Reflectivity during night time:</td><td rowspan="6">Bi-Annually</td><td rowspan="6">As per Annexure-E of IRC 35-2015</td><td rowspan="6"></td><td rowspan="6">Cat-1 Defect - within 24 hrs, Cat-2 Defect - within 2 months</td></tr>
<tr><td>Sl. No</td><td>Design Speed</td><td colspan="2">(RL) Retro-reflectivity (mcd/m2/lux)</td></tr>
<tr><td></td><td></td><td>Initial</td><td>Minimum Threshold Level (TL) and warranty period required upto 2 years</td></tr>
<tr><td>1</td><td>Up to 65</td><td>200</td><td>80</td></tr>
<tr><td>2</td><td>65-100</td><td>250</td><td>120</td></tr>
<tr><td>3</td><td>Above 100</td><td>350</td><td>150</td></tr>
<tr><td colspan="4">Initial and minimum performance for night visibility under wet condition (Retro Reflectivity)
• Initial 7 days Retro-Reflectivity: 100mcd/m^2/lux
• Minimum Threshold level:100 mcd/m^2/lux</td></tr>
</table>

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair
	Skid Resistance	Initial and minimum performance for skid resistance: • Initial (7 days): 55BPN • Min Threshold: 44BPN *Note: shall be considered under urban/city traffic condition encompassing the location like pedestrian crossing, bus bay, bus stop cycle track intersection delineation, transverse bar marking etc.	Bi-Annually	As per Annexure-G of IRC:35-2015		Within 24 hrs
Road Signs	Shape and Position	Shape and position as per IRC: 67-2012. Signboard should be clearly visible for design speed of the section	Daily	Visual with video/image backup	Improvement of shape, in case if shape is damaged. Relocation as per requirement	48 hrs in case of mandatory signs, Cautionary and Informatory Signs (Single and Dual post sign), 15 days in case of Gantry/ Cantilever Sign Boards
	Retro reflectivity	As per specifications in IRC:67-2012	Annually	Testing of each sign board using retro reflectivity measuring device. In accordance with ASTM D4956-09	Change of signboard	48 hrs in case of mandatory signs, Cautionary and Informatory Signs (Single and Dual post sign), 1 month in case of Gantry/Cantilever Sign Boards

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair
Kerb	Kerb Height	As per IRC 86: 1983 depending upon type of kerb	Bi-Annually	Use of distance measuring tape	Raising kerb height	Within 1 month
	Kerb Painting	Functionality: Functioning of kerb painting as intended	Daily	Visual with video/image backup	Kerb Repainting	Within 7 days
Other Road Furniture	Reflective Pavement Markers (Road Studs)	Numbers and Functionality as per specification in this manual and IRC:35-2015, unless specified in Schedule-B	Daily	Counting	New Installation	Within 2 months
	Pedestrian Guardrail	Functionality: Functioning of guardrail as intended	Daily	Visual with video/image backup	Rectification	Within 15 days
	Traffic Safety Barriers	Functionality: Functioning of Safety Barriers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days
	End Treatment of Traffic Safety Barriers	Functionality: Functioning of End Treatment as intended	Daily	Visual with video/image backup	Rectification	Within 7 days
	Attenuators	Functionality: Functioning of Attenuators as intended	Daily	Visual with video/image backup	Rectification	Within 7 days
	Guard posts and Delineators	Functionality: Functioning of Guard posts and Delineators as intended	Daily	Visual with video/image backup	New installation	Within 7 days
	Overhead Sign Structures	Overhead sign structure shall be structurally adequate	Daily	Visual with video/image backup	Rectification	Within 15 days

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair
	Traffic Blinkers	Functionality: Functioning of traffic blinkers as intended	Daily	Visual with video/image backup	Rectification	Within 7 days
Highway Lighting System	Highway Lights	Illumination: Minimum 40Lux illumination on the road surface	Daily	The illumination level shall be measured with lux meter	Improvement in Lighting System	24 hrs
		No major failure in the lighting system	Daily		Rectification of Failure	24 hrs
		No minor failure in the lighting system	Monthly		Rectification of Failure	8 hrs
	Toll Plaza Canopy Lights	Minimum 40 Lux illumination on the road surface	Daily	The illumination level shall be measured with lux meter	Improvement in Lighting System	24 hrs
Trees and Plantation	Observation in a minimum head-room of 5.5m above carriageway or obstruction in visibility of road signs	No obstruction due to trees	Monthly	Visual with video/image backup	Removal of trees	Immediate
	Deterioration in health of trees and bushes	Health of plantation shall be as per requirement of specification	Daily	Visual with video/image backup	Timely watering and treatment or Replacement of trees and bushes	Within 90 days

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair
	Vegetation affecting sight line and road structures	Site line shall be free from obstruction by vegetation	Daily	Visual with video/image backup	Removal of trees	Immediate
Rest Areas	Cleaning of Toilet		Daily			Every 4hrs
	Defects in electrical, water and sanitary installation		Daily			24 hrs
Other Project Facilities and Approach Roads	Damage and deterioration in approach roads, pedestrian facilities, truck lay byes, bus bays, bus-shelters, cattle crossings, traffic aid posts, medical aid posts and other works		Daily			15 days

Table 4: Maintenance Criteria of Structures

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
Pipe/ box/slab culverts	Free waterway/ unobstructed flow section	85% of culvert normal flow area to available	2 times in a year (before and after rainy season)	Inspection by Bridge Engineer as per IRC P:35-1990 and recording of depth of silting and area of vegetation	Cleaning up soils and debris in culverts barrel after rainy season, Removal of bushes and vegetation, U/s of barrel, under barrel and D/s of barrel before rainy season	15 days before onset of monsoon and within 30 days after end of rainy season	IRC:5-2015, IRC:SP:40 and IRC:SP:113
	Leak-proof expansion joints if any	No leakage through expansion joints	Bi-Annually	Physical inspection of expansion joints as per IRC SP:35-1990 if any, for leakage strains on walls at joints	Fixing with sealant suitably	30 days or before onset of rains whichever comes earlier	IRC:SP:40 and IRC SP:69
	Structurally sound	Spalling of concrete not more than 0.25 sq.m	Bi-Annually	Detailed inspection of all components of culverts as per IRC: SP:35-1990 and recording the defects	Repairs to spalling, cracking, delamination, rusting shall be followed as per IRC: SP: 40-1993	15 days	IRC:SP:40 and MoRT&H specifications clause 2800

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
		Delamination of concrete not more than 0.25sqm					
		Cracks wider than 3mm not more than 1m aggregate length					
	Protection works in good condition	Damaged of rough stone apron and bank revetment not more than 3sq.m, damage to solid apron (concrete apron) not more than 1 sq.m	2 times in a year (before and after rainy season)	Condition survey as per IRC: SP:35-1990	Repairs to damaged aprons and pitching	30 days after defect observation or 2 weeks before onset of rainy season whichever is earlier	IRC:SP:40 and IRC SP:13-2004
Bridge-Super Structure		No bump at expansion joint	Daily	Visual Inspection as per IRC: SP: 35-1990	Repairs to BC on either side of expansion joint, profile correction course on approach slab in case of settlement to approach embankment	15 days	MoRT&H specification 3004.2 and 2811

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
	User safety (condition of crash barrier and guard rail)	No damaged or missing stretch of crash barrier or pedestrian hand railing	Daily	Visual Inspection and detailed condition survey as per IRC: SP: 35-1990	Repairs and replacement of safety barriers the case may be	3 days	IRC:5-2015, IRC:SP:99 and IRC: SP:40-2019
	Rusted Reinforcement	Not more than 0.25 sq. m	Bi-Annually	Detailed condition survey as per IRC SP:35-1990	All the corroded reinforcement shall need to be thoroughly cleaned from rusting and applied with anti-corrosive agents	15 days	IRC:SP:40-2019 and MoRT&H Specification 1600
	Spalling of concrete	Not more than 0.50 sq. m					
	Delamination	Not more than 0.50 sq. m	Bi-Annually	Visual inspection	Corrosive coating before carrying out the repairs to affected concrete portion with epoxy mortar/concrete	3 days	-
	Cracks wider than 0.30mm	Not more than 1m total length	Bi-Annually	Detailed condition survey as per IRC SP:35-1990	Grouting with epoxy mortar investigating causes for crack development and carry out necessary rehabilitation	48 hrs	IRC SP:40-2019 and MoRT&H Specification 2800

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
	Rainwater seepage through deck slab	Leakage-nil	Quarterly	Detailed condition survey as per IRC SP:35-1990	Grouting of deck slab at leakage areas, water proofing, repairs to drainage spouts	1 month	MoRT&H Specification 2600 & 2700
	Deflection due to permanent loads and live loads	Within design limits	Once in every 10 yrs. for spans more than 40m	Load test method	Carry out major rehabilitation works on bridge to retain original design load capacity	6 months	IRC:SP:51-2015
	Vibrations in bridge deck due to moving tracks	Frequency of vibrations shall not be more than 5Hz	Once in every 5yr for spans more than 30m and every 10yr for spans between 15 to 30m	Laser displacement sensors or laser vibro-meters	Strengthening of superstructure	4 months	AASHTO LRFD Specification
	Leakage in expansion joints	No damage to elastomeric sealant compound in strip seal expansion joint, no leakage of rainwater through expansion joint in case buried and asphalt plug and copper strip joint	Bi-Annually	Detailed condition survey as per IRC SP:35-1990	Replace of seal in expansion joint	15 days	MoRT&H specifications 2600 and IRC:SP:40-2019

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
	Debris and dust in strip seal expansion joint	No dust or debris in expansion joint gap	Monthly	Detailed condition survey as per IRC SP:35-1990	Cleaning of expansion joint gap thoroughly	3 days	MoRT&H specifications 2600 and IRC:SP:40-2019
	Drainage Spouts	No down take pipe missing/ broken below soffit of the deck slab. No silt, debris, clogging of drainage spout collection chamber	Monthly	Detailed condition survey as per IRC SP:35-1990	Cleaning of drainage spouts thoroughly. Replacement of missing/broken down take pipes with a minimum pipe extension of 500mm below soffit of slab. Providing sealant around the drainage spout if any leakages observed	3 days	MoRT&H specifications 2700
Bridge-Super Structure	Cracks/spalling of concrete/ rusted steel	No cracks, spalling of concrete and rusted steel	Bi-Annually	Detailed condition survey as per IRC SP:35-1990	All the corroded reinforcement shall need to be thoroughly cleaned from rusting and applied with anti-corrosive coating before carrying out repairs to substructure by grouting/ guiniting and micro concreting depending on type of defect noticed	30 days	IRC:SP:40-2019 and MoRT&H specification 2800

Asset Type	Performance Parameter	Level of Service (LOS)	Frequency of Measurement	Testing Method	Recommended Remedial Measures	Time limit for Rectification/ Repair	Specification and Standard
	Bearings	Delamination of bearing reinforcement more than 5% cracking or tearing of rubber not more than 2 locations per side, no rupture of reinforcement or rubber	Bi-Annually	Detailed condition survey as per IRC SP:35-1990	In case of failure of even one bearing on any pier/abutment, all the bearings on that pier/ abutment shall be replaced, in order to get uniform lord transfer on to bearings	3 months	MoRT&H specification 2810, IRC:83 and IRC:SP:40-2019
Bridge Foundation	Scouring around foundations	Scouring shall not be lower than maximum scour level for the bridge	Bi-Annually	Condition survey and visual inspection as per IRC: SP:35-1990	Suitable protection works around pier/ abutment	1 month	IRC:SP:40-2019 and MoRT&H specification 2500

APPENDIX – 1

(Refer Clause 1.4)

Indian Road Congress (IRC): Codes of Practice, Guidelines & Standards

Sr.No.	Code/ Document No.	Title of the Publication
1.	IRC:2	Route Marker Signs for National Highways
2.	IRC:3	Dimensions & Weights of Road Design Vehicles
3.	IRC:5	Standard Specifications and Code of Practice for Road Bridges, Section I – General Features of Design
4.	IRC:6	Standard Specifications and Code of Practice for Road Bridges, Section II – Loads and Stresses
5.	IRC:8	Type Designs for Highway Kilometre Stones
6.	IRC:9	Traffic Census on Non-Urban Roads
7.	IRC:15	Standard Specifications and Code of Practice for Construction of Concrete Roads
8.	IRC:16	Standard Specifications and Code of Practice for Prime and Tack Coat (Second Revision)
9.	IRC:18	Design Criteria for Prestressed Concrete Road Bridges (Post-Tensioned Concrete)
10.	IRC:22	Standard Specifications and Code of Practice for Road Bridges, Section VI – Composite Construction (Limit States Design) (Second Revision)
11.	IRC:24	Standard Specifications and Code of Practice for Road Bridges, Steel Road Bridges (Limit State Method)
12.	IRC:25	Type Designs for Boundary Stones
13.	IRC:26	Type Design for 200-Metre Stones
14.	IRC:30	Standard Letters and Numerals of Different Heights for Use on Highway Signs
15.	IRC:32	Standard for Vertical and Horizontal Clearances of Overhead Electric Power and Telecommunication Lines as Related to Roads
16.	IRC:34	Recommendations for Road Construction in Areas Affected by Water Logging, Flooding and/or Salts Infestation
17.	IRC:35	Code of Practice for Road Markings
18.	IRC:38	Guidelines for Design of Horizontal Curves for Highways and Design Tables

Sr.No.	Code/ Document No.	Title of the Publication
19.	IRC:44	Guidelines for Cement Concrete Mix Design for Pavements
20.	IRC:45	Recommendations for Estimating the Resistance of Soil Below the Maximum Scour Level in the Design of Well Foundations of Bridges
21.	IRC:56	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control
22.	IRC:57	Recommended Practice for Sealing of Joints in Concrete Pavements
23.	IRC:58	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways
24.	IRC:67	Code of Practice for Road Signs
25.	IRC:73	Geometric Design Standards for Rural (Non-Urban) Highways
26.	IRC:75	Guidelines for the Design of High Embankments
27.	IRC:78	Standard Specifications and Code of Practice for Road Bridges, Section VII – Foundations and Substructure
28.	IRC:79	Recommended practice for Road Delineators
29.	IRC:82	Code of Practice for Maintenance of Bituminous Surface of Roads
30.	IRC:83 (Part-I)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part I : Metallic Bearings
31.	IRC:83 (Part-II)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part II: Elastomeric Bearings
32.	IRC:83 (Part-III)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings, Part III: POT, PIN, Metallic Guide and Plain Sliding Bearings
33.	IRC:83 (Part-IV)	Standard Specifications and Code of Practice for Road Bridges, Section IX – Bearings (Spherical & Cylindrical)
34.	IRC:87	Guidelines for Formwork, False work and Temporary Structures
35.	IRC:89	Guidelines for Design and Construction of River Training & Control Works for Road Bridges
36.	IRC:103	Guidelines for Pedestrian Facilities
37.	IRC:104	Guidelines for Environmental Impact Assessment of Highway Projects
38.	IRC:107	Tentative Specifications for Bitumen Mastic Wearing Courses
39.	IRC:108	Guidelines for Traffic Prediction on Rural Highways

Sr.No.	Code/ Document No.	Title of the Publication
40.	IRC:111	Specifications for Dense Graded Bituminous Mixes
41.	IRC:112	Code of Practice for Concrete Road Bridges
42.	IRC:115	Guidelines for Structural Evaluation and Strengthening of Flexible Roads Pavements using Falling Weight Deflectometer (FWD) Techniques
43.	IRC:120	Recommended practice for Recycling of Bituminous Pavements
44.	IRC:SP:13	Guidelines for the Design of Small Bridges and Culverts
45.	IRC:SP:16	Guidelines for Surface Evenness of Highway Pavements
46.	IRC:SP:19	Manual for Survey, Investigation and Preparation of Road Projects
47.	IRC:SP:21	Guidelines on Landscaping and Tree Plantation
48.	IRC:SP:23	Vertical Curves for Highways
49.	IRC:SP-42	Guidelines on Road Drainage
50.	IRC:SP:47	Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Prestressed and Composite Concrete)
51.	IRC:SP-48	Hill Road Manual
52.	IRC:SP:49	Guidelines for the Use of Dry Lean Concrete as Sub-base for Rigid Pavement
53.	IRC:SP-50	Guidelines on Urban Drainage
54.	IRC:SP:53	Guidelines on Use of Modified Bitumen in Road Construction
55.	IRC:SP:54	Project Preparation Manual for Bridges
56.	IRC:SP-55	Guidelines for Safety in Construction Zones
57.	IRC:SP:58	Guidelines for Use of Flyash in Road Embankments
58.	IRC:SP:63	Guidelines for the Use of Interlocking Concrete Block Pavement
59.	IRC:SP:69	Guidelines & Specifications for Expansion Joints (FirstRevision)
60.	IRC:SP:70	Guidelines for the Use of High Performance Concrete in Bridges
61.	IRC:SP:71	Guidelines for Design and Construction of Pretensioned Girder of Bridges
62.	IRC:SP:80	Guidelines for Corrosion Prevention, Monitoring and Remedial Measures for Concrete Bridge Structures
63.	IRC:SP-83	Guidelines for Maintenance, Repairs & Rehabilitation of Cement Concrete Pavements
64.	IRC:SP-85	Guidelines for Variable Message Signs
65.	IRC:SP-88	Road Safety Audit Manual

Sr.No.	Code/ Document No.	Title of the Publication
66.	IRC:SP-89	Guidelines for Soil and Granular Material Stabilization Using Cement Lime and Fly Ash
67.	IRC:SP-90	Manual for Grade Separators and Elevated Structures
68.	IRC:SP-91	Guidelines for Road Tunnels
69.	IRC:SP-93	Guidelines on Requirements for Environmental Clearance for Road Projects
70.	IRC:SP-102	Guidelines for Design and Construction of Reinforced Soil Walls
71.	IRC:SP-112	Manual for Quality Control in Road and Bridge works

APPENDIX – 2

(Refer Clause 1.12)

List of Paras for preparing schedules of the Concession Agreement (Refer Para 1.12)

Section	Para	Particulars to be specified
Schedule A		
Section 2	2.3.1	Right of Way (ROW) and land to be acquired
Schedule B		
Section 2	2.11.2	List of sections where radius of curve less than desirable minimum
	2.13.1	(i) Type of structure for vehicular underpass or overpass and whether cross road shall be carried at the existing level or raised/lowered. (ii) Stretches where the Project Expressway shall be elevated or viaduct.
	2.13.2	Type, location, length, number and opening required and approach gradient for various grade separated structures
	2.13.3	Length of RCC Toe or retaining wall / RE wall.
	2.14	Lateral and Vertical clearance for different categories of Underpasses.
Section 3	3.2 and 3.3.1	Location and type of grade separated structures, interchanges, other features and land requirements
	3.2.1.2	Length of viaduct of grade separated structures
Section 5	5.2.1	Type of pavement
	5.3.2	Standards for Design of Rigid Pavement
	5.9.5	Stretches of Expressway for reconstruction
Section 6	6.1	Provision of structures, initial configuration
	6.4 (vii)	Requirement of special structures like cable stayed/ superstructure bridge, etc.
	6.4(viii)	Span length of structures
	6.14	Replacement of Wearing Coat
	6.19	Location, type and length of Grade separated structures
Section 7	7.1.3	Requirement of Tunnel – Locations, length and number of lanes

Section	Para	Particulars to be specified
Section 9	9.2.1	Minimum length of Drains
Section 10	10.6	Traffic Impact Attenuators
Schedule C		
Section 10	10.2.8	Location and size of Over Head Signs
Section 11	11.1	Location of each component of ATMS
Section 12	12.1	Fee collection system (if other than ETC)
Section 13	13.1.2	Location of Service Areas, Toilet Facilities
	13.2.2	Location of Pick-up Bus Stops
	13.3.2	Location of Border Check Post
Section 14	14.3.1	Number of Trees to be planted
	14.4	Locations for landscape treatment
Section 15	15.1 (i) and 15.4	Locations for providing lighting
Schedule D		
Section 6	6.18.1	Deviation regarding ROB / RUB with respect to para 6.3, if any

(The Official amendments to this document would be published by the IRC In its periodical, 'Indian Highways' which shall be considered as effective and as part of the code/guidelines/manual, etc. from the date specified therein)

Price : ₹ 1500/-
(Plus Packing & Postage)